TRANSITION AND WELLBEING RESEARCH PROGRAMME

IMPACT OF COMBAT STUDY

Impact of Combat

2019

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The Department of Defence
http://www.defence.gov.au/Health/DMH/ResearchSurveillancePlan.asp

The Department of Veterans' Affairs
www.dva.gov.au/impact-combat-report

Key findings

Introduction

The Impact of Combat Study examines changes over time in the mental, physical and neurocognitive health and wellbeing of participants in the Middle East Area of Operations (MEAO) Prospective Health Study, who deployed to the MEAO between 2010 and 2012. It represents the third wave of data collection for this cohort.

The present study is part of the Transition and Wellbeing Research Programme, which is the most comprehensive Australian study of the impact of military service on the mental, physical and social health of serving and ex-serving ADF members and their families. The Programme is made up of three studies with this report being the sole report under the Impact of Combat Study; the other two studies are the Mental Health and Wellbeing Transition Study and the Family Wellbeing Study.

The *Impact of Combat Report*:

- investigates the longitudinal course of mental disorder in ADF members deployed to the MEAO between June 2010 and June 2012

- characterises the deployment and non-deployment risk factors associated with poor mental health outcomes – including an investigation of the role of combat exposure

- examines the long-term trajectory for resilient ADF members following deployment

- examines the interaction between pre-deployment trauma and deployment-related trauma

- investigates deployment-related mild traumatic brain injury.

The sample for the study was the MEAO Deployed Cohort, which consisted of 1350 Regular and Transitioned ADF members who deployed to the MEAO after June 2010, returned before June 2012, completed a pre-deployment and/or post-deployment health survey as part of the MEAO Prospective Study in 2010–2012, and were included on the Programme's Military and Veteran Research Study Roll. Of the 1350 members of this cohort, 26.5% (n = 129) of those who transitioned and 49.9% (n = 431) of those

who remained in the Regular ADF completed a survey at Time 3. Within this cohort are three nested subgroups:

- the Combat Zone Subgroup, consisting of individuals who participated in a Composite International Diagnostic Interview (Phase 2) and a blood test (Phase 3) in addition to the self-report survey (Phase 1)

- the Combat Role High-risk Subgroup, consisting of individuals who were invited to participate in a Composite International Diagnostic Interview, a blood test and a neurocognitive assessment battery (Phase 4)

- the mTBI Subgroup, consisting of individuals who completed Phases 1 to 4 of testing and participated in a magnetic resonance imaging assessment (Phase 5). These individuals were selected because they had previously completed a neurocognitive assessment as part of the MEAO Prospective Study and were identified as having high combat and blast exposure.

The results of the study suggest that the majority of the MEAO deployed cohort is healthy. Rates of psychological and physical symptoms and disorder increased over time in the cohort, yet the substantial majority remained below screening thresholds. A range of biological markers were also assessed in a subset of Regular and Transitioned ADF, and in general these were well within the normal ranges for a healthy population.

In accordance with a previous report from the Programme, the *Mental Health Prevalence Report*, the Transitioned cohort generally experienced significantly poorer mental and physical health than those still in the ADF in 2015. Specifically, Transitioned ADF members generally reported higher posttraumatic stress and depressive symptoms, psychological distress, pain and disability than the 2015 Regular ADF cohort. The Transitioned cohort also had a higher prevalence of disorder. In the entire cohort, anxiety disorders were the most prevalent 12-month disorders and alcohol and anxiety disorders were the most prevalent lifetime disorders.

For all mental health measures – particularly depression, psychological distress and PTSD – there was a significant increase in the proportion of the overall cohort scoring above the screening (subsyndromal) and epidemiological cut-offs (probable disorder) with the passage of time. Nevertheless, only relatively few met probable disorder criteria at the latest follow-up. The results underscore subsyndromal symptoms as a possible indicator of risk for future progression to diagnosable disorder. Small changes were observed in the biological markers measured over time, and for a number of markers no changes were found, although there were some consistent patterns of change across group measures.

The number of combat exposures during an individual's military career was a significant predictor of elevated psychological distress and posttraumatic symptoms at the latest follow-up, and the number of physical health symptoms reported was higher among subgroups with elevated psychological distress or posttraumatic stress symptoms at all time points. There was evidence that participants with elevated psychological distress versus posttraumatic stress symptoms exhibit distinct trajectories and that increasing levels of subsyndromal distress observed in this cohort occur alongside a corresponding increase in suicidality, alcohol use and anger.

As part of this study neurocognitive data were collected on a subset of the entire cohort (the High-risk Combat Role and mTBI subgroups). The overall pattern of findings suggests that initial deployment and combat exposure may have lasting impacts on resting brain states and attentional and memory processes. An analysis of traumatic brain injury was also done: it showed a high self-reported prevalence of these events and possible associations between blast exposure and structural changes in the brain.

In summary, the Impact of Combat Study documents the health and functioning of a healthy deploying cohort of ADF members. Relatively few met probable disorder criteria. The results suggest, however, a progressive recruitment of symptoms and distress with the passage of time across a range of measures of self-reported symptomatic distress and for biological and neurocognitive functioning. Such results are indicative of subsyndromal indicators of risk. The study highlights the importance of examining subgroups in the broader cohort – particularly the differences in the symptom trajectories of those who were more symptomatic compared with those who remained relatively symptom free at the latest time point.

Further results are summarised in the remainder of this 'Key findings' section. The glossary provides definitions of terms used.

Response rates and demographics

Response rates and basic cohort characteristics

- A total of 1350 members of the cohort who participated in the MEAO (Middle East Area of Operations) Prospective Health Study (Times 1 and 2) were invited to participate in the Impact of Combat Study (Time 3). Of these, 486 were transitioned and 864 remained in the Regular ADF. For the survey component, there was a response rate of 26.5% for the Transitioned ADF members and 49.9% for the 2015 Regular ADF members. When examined within each nested subgroup, the response rates were similar.

- The distribution of medical fitness for responders compared with non-responders was similar. The majority of Transitioned ADF (83.6%) and 2015 Regular ADF (86.6%) responders were classified as fit.

Demographic characteristics

- The majority of cohort members were in a relationship and living together (68.0%).

- The majority of cohort members had completed educational qualifications of certificate level or above (58.8%); about one-third had completed primary or secondary school only.

- Among those who had transitioned from the ADF, 71.3% were in full- or part-time work, just under 10% were receiving a sickness allowance or disability support pension, 7.0% were students, and 3.5% were retired.

- A total of 90.0% of the cohort reported being in stable housing at the time of the survey; the figure was slightly lower for those who had transitioned (87.0%).

- A total of 27.1% of the cohort were DVA clients; 45.2% of these individuals were transitioned ADF members.

Transitioned cohort members

- The Transitioned ADF cohort members consisted of 44.3% Inactive Reservists, 30.4% who were Ex-Serving and 24.3% Active Reservists.

- The majority had discharged at their own request (68.7%), and 8.7% reported a medical discharge.

- About two-thirds were in employment (65.2%), the majority of these individuals working between 21 and 60 hours a week.

- Just over one in three reported a period of unemployment lasting at least three months since transition (34.8%).

- In relation to DVA support, one in three (34.8%) reported treatment support of some form (White or Gold Card).

Longitudinal health status

Mental health

- For all mental health measures there were small to moderate increases in symptoms over time and, correspondingly, small to moderate increases in the proportion of the cohort with subsyndromal or probable disorder.

Depressive symptoms

- Average depressive symptoms were low in the cohort at all time points but did increase with time, the largest change occurring between Times 2 and 3 (M = 2.5 vs M = 5.1).

- The majority of cohort members fell below both screening and epidemiological cut-offs for probable depressive episodes at Time 1 (91.5%), Time 2 (86.2%) and Time 3 (66.7%), there being a steady increase in the proportion with subsyndromal and probable disorder over time. At Time 3, 27.9% of the cohort were subsyndromal and 5.4% had probable depressive episodes.

Psychological distress

- Average psychological distress symptoms were low in the cohort at all time points. They were relatively stable between Time 1 (M = 13.4) and Time 2 (M = 13.8) and increased at Time 3 (M = 16.6).

- The majority of the MEAO Deployed Cohort fell below both screening and epidemiological cut-offs for probable psychological distress at Time 1 (84.1%), Time 2 (79.4%) and Time 3 (69.6%). The proportion of the cohort who were subsyndromal increased from Time 1 (12.1%) to Time 2 (16.6%), then remained stable at Time 3 (16.4%).

- A different pattern was observed in the case of probable disorder: the proportion of the cohort with probable psychological distress did not change between Time 1 (3.7%) and Time 2 (4.0%) but increased significantly at Time 3 (14.0%).

Posttraumatic stress symptoms

- There were small increases in mean posttraumatic stress symptoms in the cohort from Time 1 (M = 20.0) to Time 2 (M = 22.3) and again at Time 3 (M = 25.3).

- The majority of the cohort scored below subsyndromal and probable disorder cut-offs at Time 1, Time 2 and Time 3.

- The proportion of the cohort with subsyndromal posttraumatic stress symptoms nearly doubled from Time 1 (7.1%) to Time 2 (13.4%) and increased again, to 21.7%, at Time 3. The proportion of the cohort with probable PTSD was very low at all three time points but showed the same pattern of increase over time (Time 1, 0.2%; Time 2, 1.7%; Time 3, 3.6%).

Alcohol use and problem drinking

- There was very little variation in mean AUDIT (Alcohol Use Disorders Identification Test) scores over time in the cohort, there being no change from Time 1 (M = 6.3) to Time 2 (M = 6.6) and only a small increase at Time 3 (M = 8.9).

- Almost three-quarters of the cohort fell below subsyndromal and probable alcohol disorder cut-offs at Time 1 (71.2%) and Time 2 (72.1%); the proportion fell slightly, to 67.5%, at Time 3. Almost one-third of the cohort scored above the screening cut-off on the AUDIT at Time 1 (28.1%), Time 2 (26.0%) and Time 3 (29.6%).

- Rates of probable alcohol disorder were extremely low in the cohort but showed a pattern of increase over time (Time 1, 0.7%; Time 2, 1.9%; Time 3, 2.9%).

Anger symptoms

- Mean anger scores increased over time (Time 1, M = 6.7; Time 2, M = 7.3; Time 3, M = 8.5). The proportion of participants with problematic anger also increased steadily from Time 1 through to Time 3 (Time 1, 5.5%; Time 2, 11.6%; Time 3, 19.2%).

Suicidality

- The proportion of the cohort with any suicidality increased slightly from Time 1 (2.2%) to Time 2 (3.6%) and increased dramatically at Time 3 (12.7%).

- No members of the cohort reported formulating a suicide plan or attempting suicide at Time 1 or Time 2; at Time 3, 2.6% of the cohort reported making a plan and 1.0% had made an attempt.

Lifetime and 12-month ICD-10 disorder

- Overall, members of the cohort who had transitioned from the ADF reported higher lifetime and 12-month rates of each ICD-10 mental disorder class compared with those who remained in the Regular ADF.

- Almost 80% of the cohort who had transitioned in 2015 met criteria for any lifetime ICD-10 mental disorder; this compares with two-thirds (66.7%) of those who remained in the Regular ADF.

- One in two cohort members who had transitioned met criteria for a mental health disorder in the preceding 12 months; this compares with about one in five of those who remained in the Regular ADF.

- Alcohol (Transitioned ADF, 59.7%; 2015 Regular ADF, 47.4%) and anxiety disorders (Transitioned ADF, 55.6%; 2015 Regular ADF, 32.5%) were the most prevalent lifetime disorder classes for the cohort. The rates of affective disorders were lower (Transitioned ADF: 37.5%; 2015 Regular ADF: 18.4%).

- Lifetime rates of PTSD were 29.2% for cohort members who had transitioned and 13.2% for those who had remained in the Regular ADF.

- Anxiety disorders were the most prevalent 12-month disorders in the cohort: 41.7% of transitioned cohort members and 18.4% of those who were still regular serving members met the ICD-10 criteria.

- Rates of 12-month alcohol disorders were low in the cohort, and the disorders were more commonly reported among members who had transitioned. The most common 12-month alcohol disorder class was alcohol dependence (Transitioned ADF, 9.7%; 2015 Regular ADF, 3.5%).

Physical health

- The mean number of physical health symptoms reported increased from Time 1 (M = 7.7, SE = 0.4) to Time 2 (M = 10.4, SE = 0.5) and was higher again at Time 3 (M = 12.8, SE = 0.5).

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- Over 50% of participants fell within the pre-obese range (53.7%) at Time 1. This proportion increased to almost 60% (58.9%) at Time 2 and was higher still at Time 3 (66.3%).

Biological measures

- Overall, biological outcomes were well within the normal ranges for a healthy population. Only small changes were observed in the outcomes measured and for a number of markers no changes were found, although there were some consistent patterns of change across groups of measures.

- A number of markers – interleukin 6, tumor necrosis factor alpha, C-reactive protein, cortisol and brain-derived neurotrophic factor – showed a pattern of increase between Time 1 and Time 2 and a subsequent decrease at Time 3.

Predicting long-term mental health

Psychological distress

- Previous deployments and career deployment exposure history were associated with elevated psychological distress at Time 3. Specifically:

    – The more previous deployments cohort members had before the index deployment, the greater the likelihood of having elevated psychological distress at Time 3.

    – Those with high or very high levels of deployment exposure were three times more likely to have elevated psychological distress at Time 3 compared with those with very low or low exposure.

Posttraumatic stress

- The number of lifetime trauma exposure types and career deployment exposure history were associated with elevated posttraumatic stress symptoms at Time 3. Specifically:

    – The number of lifetime trauma exposure types at Time 1 was a significant predictor of elevated posttraumatic stress symptoms at Time 3.

    – Cohort members with medium, high or very high levels of deployment exposure were three to five times more likely than those with very low exposures to have elevated posttraumatic stress symptoms at Time 3.

Physical health correlates of long-term mental health

- Cohort members with elevated psychological distress or posttraumatic stress symptoms at Time 3 reported higher numbers of physical health symptoms at all three time points.

- In general, pro-inflammatory markers were lower across time among those with elevated psychological distress or posttraumatic stress symptoms at Time 3.

Neurocognitive function

Neurocognitive function over time

The overall pattern of findings suggests that initial deployment and combat exposure can have lasting effects on resting brain state and attentional and memory processes.

Quantitative electroencephalography

- Beta power and alpha power showed reductions from Time 1 to Time 2 and these were sustained at Time 3. This is indicative of reduced cognitive engagement and reduced relaxed wakefulness. In contrast, theta and delta power increased from Time 1 to Time 2 and elevations were sustained at Time 3, suggesting an increase in memory processing.

Working memory[1]

- Reductions in P3 working memory amplitudes were observed over time, with successive reductions from Time 1 to Time 2 and then to Time 3. The reductions were most notable at the frontal and central electrodes. This component provides an objective measure of working memory functioning, and its amplitude is a measure of the efficiency of processing, greater amplitude reflecting greater efficiency. The observed reductions are thus consistent with reduced efficiency of memory processes.

Neurocognitive function and elevated psychological distress and posttraumatic stress

Deployment appears to have an acutely altering effect on functioning within attentional orientation networks. The findings were as follows:

- Functional decrements in attentional networks were evident among ADF members with low psychological symptoms at Time 3 and those with elevated posttraumatic stress symptoms.

- Attentional hypervigilance was evident among those with elevated psychological distress symptoms at Time 3.

- Acute deployment-related effects appear to resolve in those with low symptoms or elevated psychological distress symptoms at Time 3.

- Acquired functional decrements appear to be progressively exacerbated in those with elevated posttraumatic stress, with executive memory network impairments also becoming evident in the long term.

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[1] The amplitude of the P3 is an indicator of the efficiency of processing, whereby greater amplitude reflects greater efficiency, so where working memory efficiency is discussed this reflects changes or differences in P3 amplitude. It should be noted that, while ERP data are used as a measure of working memory in this study, no corresponding neuropsychological assessments of working memory were included.

Quantitative electroencephalography

- Together, the findings suggest that individuals who manifest psychological symptoms over time exhibit a range of distinct qEEG characteristics, with beta and theta power bands bearing the closest association with current psychological symptom status at Time 3. It appears that higher beta and theta power levels at Time 1 could potentially be vulnerability markers for the emergence of future psychological symptoms.

Working memory

- ERP (event-related potential) indices could serve as a marker of emerging subsyndromal distress in this population, with findings indicative of acutely acquired (that is, deployment-related) attentional network impairments followed by progressive exacerbation of these in the longer term. Although deployment appears to predominantly affect anterior attentional network functions, there could be progressive impacts on posterior executive memory network functions in the longer term. The findings also provide evidence that fronto-central amplitude reductions can pre-exist PTSD symptom onset, although these deficits might reflect higher cumulative trauma exposure and early signs of symptom development.

Injuries to the head and traumatic brain injury

Reported traumatic brain injury in Transitioned ADF and 2015 Regular ADF

Injuries to the head

- Similar proportions of Transitioned ADF members and 2015 Regular ADF members reported experiencing all types of injuries to the head except for injuring their head or neck in a fall/being hit by something (a lower proportion) or being nearby when an explosion/blast occurred (a greater proportion).

- Similar proportions of Transitioned ADF and 2015 Regular ADF reported that their injuries occurred during military service.

- The most commonly reported context for experiencing a head injury during cohort members' lifetime was being nearby when an explosion or blast occurred (Transitioned ADF, 69.7%; 2015 Regular ADF, 49.9%).

Reported lifetime traumatic brain injury and mild traumatic brain injury

- Similar proportions of Transitioned ADF and 2015 Regular ADF reported experiencing any TBI (mild, moderate or severe) in their lifetime (49.1% vs 47.4%).

- 2015 Regular ADF reported a higher mean number of lifetime TBIs than Transitioned ADF (M = 4.9 vs M = 3.4).

- The great majority of reported lifetime TBI was mild TBI: only four Transitioned ADF members (3.7%) and eleven 2015 Regular ADF members (2.9%) reported moderate or severe lifetime TBI.

Mental health, functional outcomes and post-concussive symptoms in cohort those with reported lifetime traumatic brain injury

- Transitioned ADF members generally had higher levels of posttraumatic stress symptoms, psychological distress and depressive symptoms than 2015 Regular ADF members, and this pattern was similar when comparing those with and without reported TBI.

- Within both the Transitioned ADF and the 2015 Regular ADF groups, posttraumatic stress symptoms, psychological distress and depressive symptoms were similar between those with and without reported TBI.

- Transitioned ADF (M = 10.7) and 2015 Regular ADF (M = 7.5) who reported lifetime TBI showed slightly higher scores on total global functioning impairment compared with those with no TBI (M = 8.8 and M = 4.9) and across all three domains of disability.

- Transitioned ADF generally had higher scores on total global functioning impairment than 2015 Regular ADF, and this pattern was similar when comparing those with reported TBI and those without reported TBI across the two groups, as seen for the psychological disorders.

- Mean post-concussion syndrome scores were greater among Transitioned ADF with a reported TBI (M = 6.2) compared with those with no reported TBI (M = 3.0). Mean PCS scores were similar in 2015 Regular ADF with a reported TBI compared with those with no reported TBI.

- Mean post-concussion syndrome scores were higher in Transitioned ADF (those with reported TBI and those without) compared with the respective subgroups in the 2015 Regular ADF.

Contents

Tables

Figures

Acknowledgements

Study participants

First and foremost, we acknowledge all current and ex-serving ADF personnel who generously gave their time to complete the study. This research was only made possible by their efforts and commitment to the study. Other key individuals include:

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Transition and Wellbeing Research Programme Scientific Advisory Committee

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The Transition and Wellbeing Research Programme – an overview

Transition and Wellbeing Research Programme

The Programme consists of three studies comprising eight reports and two papers: the Mental Health and Wellbeing Transition Study (five reports and two papers), the Impact of Combat Study (one report) and the Family Wellbeing Study (one report). The Programme of research is summarised in the Transition and Wellbeing Research Programme Key Findings Report.

Mental Health and Wellbeing Transition Study

- Mental Health Prevalence
- Pathways to Care
- Physical Health Status
- Technology Use and Wellbeing
- Mental Health Changes Over Time: a Longitudinal Perspective
- Health and Wellbeing of ADF Reservists Paper
- Psychosocial Predictors of Health Paper

Impact of Combat Study
- Impact of Combat

Family Wellbeing Study
- Family Wellbeing

Transition and Wellbeing Research Programme Key Findings Report

The Transition and Wellbeing Research Programme is the most comprehensive study undertaken in Australia to examine the impact of military service on the mental, physical and social health of:

- serving and ex-serving Australian Defence Force members, including those who have been deployed in contemporary conflicts, and

- their families.

This research further extends and builds on the findings of the world-leading research conducted with current serving members of the ADF in the 2010 Military Health Outcomes Program (MilHOP).

The current research, conducted in 2015, arises from the collaborative partnership between the Department of Veterans' Affairs and the Department of Defence. It aims to implement the government's goal of ensuring that current and future policy,

programs and services are responsive to the current and emerging health and wellbeing needs of serving and ex-serving ADF members and their families before, during and after transition from military life.

Ten objectives were developed to guide the Programme. The objectives are being realised through three studies comprising eight reports – the Mental Health and Wellbeing Transition Study (five reports and two papers), the Impact of Combat Study (one report), the Family Wellbeing Study (one report) and the *Transition and Wellbeing Research Programme Key Findings Report*, which summarises the research, as the diagram above shows. The following table shows which reports deliver on the objectives. This report, the *Impact of Combat Report*, addresses the ninth objective, which is to follow up on the mental, physical and neurocognitive health and wellbeing of participants who deployed to the Middle East Area of Operations between 2010 and 2012.

Programme objectives	Corresponding reports and papers
1. Determine the prevalence of mental disorders among ADF members who have transitioned from Regular ADF service between 2010 and 2014. 2. Examine self-reported mental health status of Transitioned ADF and the 2015 Regular ADF.	*Mental Health Prevalence Report*
3. Assess pathways to care for Transitioned ADF and the 2015 Regular ADF, including those with a probable 30-day mental disorder.	*Pathways to Care Report*
4. Examine the physical health status of Transitioned ADF and the 2015 Regular ADF.	*Physical Health Status Report*
5. Investigate technology and its utility for health and mental health programmes including implications for future health service delivery.	*Technology Use and Wellbeing Report*
6. Conduct predictive modelling of the trajectory of mental health symptoms/disorder of Transitioned ADF and the 2015 Regular ADF, removing the need to rely on estimated rates.	*Mental Health Changes Over Time: a Longitudinal Perspective Report*
7. Investigate the mental health and wellbeing of currently serving 2015 Ab-initio Reservists.	*The Health and Wellbeing of ADF Reservists Paper*
8. Examine the factors that contribute to the wellbeing of Transitioned ADF and the 2015 Regular ADF.	*Psychosocial Predictors of Health Paper*
9. Follow up on the mental, physical and neurocognitive health and wellbeing of participants who deployed to the Middle East Area of Operations between 2010 and 2012.	*Impact of Combat Report*
10. Investigate the impact of ADF service on the health and wellbeing of the families of Transitioned ADF and the 2015 Regular ADF.	*Family Wellbeing Study*
All objectives	*Transition and Wellbeing Research Programme Key Findings Report*

Two eminent Australian research institutions, one specialising in trauma and the other in families, have led the Research Programme. The Centre for Traumatic Stress Studies at the University of Adelaide is conducting the Mental Health and Wellbeing Transition Study and the Impact of Combat Study, and the Australian Institute of Family Studies is conducting the Family and Wellbeing Study.

Their research expertise is enhanced through partner institutions from Monash University, the University of New South Wales, Phoenix Australia Centre for Posttraumatic Mental Health and, until June 2016, the Young and Well Cooperative Research Centre, the work of which is being continued at the University of Sydney.

Through surveys and interviews, the researchers engaged with a range of serving and ex-serving ADF members, including:

- ADF members who transitioned from the Regular ADF between 2010 and 2014 (including Ex-Serving, Active and Inactive Reservists)

- a random sample of Regular ADF members serving in 2015

- a sample of Ab-initio Reservists serving in 2015 (who have never been full-time ADF members)

- 2015 Regular ADF and Transitioned ADF members who participated in MilHOP

- family members nominated by the above.

The Departments of Veterans' Affairs and Defence thank the current and ex-serving ADF members and their families who participated in this research, for sharing your experiences and insights. Your efforts will help inform and assist the ways you, your colleagues, friends and families, as well as those who come after you, can best be supported during and after your military career.

1   Introduction

1.1   Background to this report

This report, the *Impact of Combat Report*, is part of the Transition and Wellbeing Research Programme and the sole report arising from the Impact of Combat Study. It examines the mental, physical and neurocognitive health and wellbeing of participants in the Middle East Area of Operations (MEAO) Prospective Health Study (Davy et al., 2012), who deployed to the MEAO between 2010 and 2012.The findings detailed in this report should be considered in the context of previous Australian and international research into mental health and wellbeing in both military and veteran populations and previous reports resulting from the Transition and Wellbeing Research Programme.

It has been well documented that a range of mental disorders, as well as physical symptoms and conditions, are associated with military service – specifically including deployment and combat exposure (Donoho et al., 2017). Furthermore, there is substantial evidence that military service might be associated with the delayed onset of many conditions, among them posttraumatic stress disorder (Andrews et al., 2007; Donoho et al., 2017). In any occupation where there is a likelihood of repeated stress exposure it is important to document the effects of this over the longer term. Although the majority of people will remain resilient in the face of traumatic exposure, health effects often might not become apparent until many years later (Carty et al., 2006; Grieger et al., 2006; Orcutt et al., 2004; Solomon et al., 1990; Southwick et al., 1995): a number of studies now show that an extensive period can elapse before these delayed effects emerge (Eekhout et al., 2016; Marmar et al., 2015; Vasterling et al., 2016). At the time of the MEAO Prospective Health Study Australia had been at war in Afghanistan for more than a decade – twice the duration of World War 2 – and more than 24,000 Australian troops had deployed to the MEAO, many of them several times (Davy et al., 2012).

War and combat have been shown to be associated with adverse health outcomes beyond merely acute combat-related injuries (Hyams et al., 1996); among those adverse outcomes are longer term biological dysregulation and the emergence of health effects many years after exposure. In the past decade, a range of non–battle related injuries have been linked to combat stress; these include psychiatric disorders such as depression, PTSD and anxiety, as well as somatic conditions such as chronic fatigue syndrome, fibromyalgia and chronic pain (Holdeman, 2009; McFarlane, 2010b).

The MEAO Prospective Health Study was designed to examine the impacts of deployment and combat exposure on a wide range of health factors relevant to deployed military populations. By collecting information on both subjective and objective measures and using a longitudinal design, the study addressed a number of methodological limitations associated with other studies of this nature and allowed for the examination of health outcomes over time (Davy et al., 2012). The study assessed a cohort of 1871 Regular serving ADF members pre- and post-index deployment to the MEAO, establishing a baseline cohort where participants' pre-deployment data could be used as a yardstick against which to measure subsequent change. The data were intended to establish a baseline for future health surveillance. A subgroup of participants who were deployed in combat roles were also assessed with a range of objective physical measures. A further nested subgroup with the highest probability of combat exposure were also assessed using neurocognitive measures. This subgroup was targeted because they were deployed as part of either the Special Operations Task Group or the Mentoring Task Force and were deemed likely to have extensive combat and blast exposure.

Findings from the MEAO Prospective Study highlighted that the majority of the cohort members were exceptionally healthy psychologically, physically and socially before and after deployment (Davy et al., 2012). This was not surprising for two main reasons. First, initial recruitment into the ADF is stringent, so the group represents a relatively healthy workforce compared with the general Australian population. Furthermore, the additional health checks that are required before deployment ensure that this cohort would have comprised some of the fittest and healthiest members of the ADF. It is of interest that, although the study found very little evidence of changes in mental or physical health between pre- and post-deployment, small but significant changes in some symptoms were identified; importantly, these were more likely to be evident in individuals with higher rates of combat and deployment exposures and among those in combat roles (Davy et al., 2012).

The Impact of Combat Study followed up all participants from the MEAO Prospective Health Study in 2015, this representing the third wave of data collection on the cohort. By this time it was up to four years since the last assessment of these participants. This is a crucial period following deployment – one during which any initial dysregulation of biological systems can begin to become manifest in a decline in health status (McFarlane, 2010b). The physical and biological data collected in the MEAO Prospective Health Study, and again in the Impact of Combat Study, allowed for the examination of such changes, and also allowed comparisons to be made between individuals with differing levels of exposure to combat and blast injury. It was hypothesised that the exposures and stresses related to deployment would lead to a pattern of subclinical dysregulation or shifts in homeostatic regulation of various

biological systems that, with the passage of time, could potentially manifest in emerging physical and psychological symptoms and disorders.

1.2 The short- and longer-term impacts of deployment to a combat zone

The short- and long-term impacts of deployment and combat exposure for military personnel have been of much interest to Defence Forces around the world, and the increasingly intensive deployment cycles in the Middle East, peacekeeping and disaster relief missions have provided an impetus to understand the potential consequences of repeated deployments and exposure to traumatic events on deployment.

An extensive body of international literature has begun to document the intermediate and longer term impacts of deployment and combat exposure in military samples. In general, although the findings are influenced by the duration of follow-up, there is substantial evidence of delayed psychological reactions to deployment and combat exposure. The majority of military personnel do well following deployment and into the future, with the risk of disorder even decreasing over time (Koenen et al., 2003; Marmar et al., 2015), but there is also evidence of a trajectory of symptom recruitment with the passage of time in a significant number of cases (Archibald & Tuddenham, 1965; Ikin et al., 2007; Solomon, 1993). For example, in the Australian Vietnam Veterans Study, rates of lifetime PTSD were found to increase over a decade, going from 20% in the 1990s to 28% in the 2000s (O'Toole et al., 2009). Importantly, these studies have focused on periods ranging from 10 to 50 years post–deployment and service (Ikin et al., 2007).

Research on the longitudinal course of psychological disorders such as PTSD suggests that their course is variable over time, with symptoms fluctuating and individuals moving in and out of diagnosable disorder (Bryant et al., 2018). The concept of mental disorder staging (McFarlane et al., 2017) posits that these fluctuations would ultimately move in an upward direction towards increased symptoms and ultimately disorder chronicity in the long term. Against this background, it is therefore of great importance to also consider symptom shifts in the intermediate term – particularly as a potential marker for future morbidity.

One of the largest longitudinal studies of the impacts of military service is the US Millennium Cohort Study (Smith et al., 2011), which was designed to evaluate the health of service personnel throughout their military career and beyond and to determine whether deployment-related exposures would be associated with post-deployment health outcomes in the short, medium and longer term (Chesbrough et al., 2002). The first data collection occurred in July 2001, when approximately 2.2 million men and women on active service rosters were surveyed to assess their physical and

functional status, as well as PTSD, alcohol and tobacco use, sleep patterns and various exposures. These subjective data were linked to US Department of Defense inpatient, ambulatory and pharmacy databases in order to ensure that some objective measures of health were also captured.

Analysis of the first wave of data showed an exceptionally healthy cohort, with generally very low levels of mental and physical health symptoms (Ryan et al., 2007). In subsequent follow-ups the study has found deployment and combat exposure to be associated with increased risk for new-onset depression, increases in various forms of alcohol misuse in both reserve and regular personnel (Gray et al., 2002) and an increased risk of new-onset PTSD symptoms (Smith et al., 2008b), the cumulative burden of lifetime trauma and continued deployment exposure exacerbating this. Interestingly, the study has also documented increased respiratory symptoms and hypertension, these being related to multiple combat traumas in particular. These associations were replicated in part in findings from the MEAO Prospective Health Study, that study revealing evidence of an association between deployment exposure and objective measures of decreased respiratory function and increased blood pressure (Davy et al., 2012).

Taking PTSD as an example, research shows that rates of PTSD and other mental disorders increase in the post-deployment period (immediate to one year after) (Vasterling et al., 2016). Eekhout et al. (2016) also found a pattern of increased PTSD symptoms in the five-year period post-deployment among a Dutch military sample. In recent further analyses from the Millennium Cohort Study the presence of elevated PTSD symptoms was *initially* found to predict the course and severity of PTSD in the longer term (Bonanno et al., 2012; Donoho et al., 2017; Jacobson et al., 2015).

There is now substantial literature highlighting the progression of subsyndromal symptoms and the later emergence of diagnosable disorder in the form of delayed-onset PTSD (Carty et al., 2006; Grieger et al., 2006; Orcutt et al., 2004; Solomon et al., 1990; Southwick et al., 1995). A number of studies following military populations over varying time periods have highlighted the long-term and progressive increase in PTSD morbidity with the passage of time following trauma (O'Toole et al., 2009; Solomon & Mikulincer, 2006).

A further body of evidence provides some explanation for this pattern of progressive symptom recruitment and delayed onset of disorder. There are physiological reasons why the stress of deployment might not become immediately manifest as a mental disorder, and it is only with the passage of time that this transition to a diagnosable disorder occurs. Specifically, there are underlying physiological mechanisms by which stress exposure can modify subsequent reactivity to challenge. Exposure to repeated stress may eventually lead to sensitisation of a range of biological systems. This results

in increasing allostatic load as a result of the up-regulation of the inhibitory systems (Marshall et al., 2001; Marshall & Garakani, 2002; McFarlane, 2010b; Post & Weiss, 1998; Weiss, 2007). At a neurobiological level, these inhibitory systems are reflected in the prefrontal–amygdala circuitry (McEwen & Wingfield, 2003; Rauch et al., 2006). Similarly, the HPA (hypothalamic–pituitary–adrenal) axis and other neuro-hormonal systems are vulnerable to these mechanisms of sensitisation (Marshall & Garakani, 2002; McEwen, 2000). Hence, when military personnel return from the combat environment and try to adapt to day-to-day life, including the normal stressors that occur in the civilian community, the dysregulation of these underlying systems modifies their adaptability. Progressively, they react to the presence of stressors with greater amplitude or intensity and ultimately develop an over-generalised reactivity to a range of stimuli that remind the person of the combat environment. The cycle of increasing reactivity to a widening range of cues serves to further reinforce any distress response. This might, however, become manifest as a diagnosable disorder only after considerable time has passed.

Against this background, it is highly probable that following deployment there will be further recruitment of symptoms – particularly in those who have had high levels of combat exposure. Equally, with the passage of time post-deployment, the rates of morbidity are likely to further increase (Bonanno et al., 2012). The progressive emergence of symptoms after injury has been well documented in civilian environments (O'Donnell, 2013), and this research highlights two particular things: that mental health status is dynamic and fluid across time and that ongoing stressors play a major role in shaping one's current mental health. People tend to change considerably in terms of their disorder status over time (Bryant et al., 2013), moving between symptom-free, subsyndromal and diagnosable disorder. Importantly, stressors experienced in the period since the initial traumatic exposure appear to strongly propel this change in symptom status with time (Bryant et al., 2017).

In the context of combat-deployed ADF members, this is of particular relevance because of the high operational tempo at the time of the MEAO Prospective Health Study: many personnel were deployed repeatedly during this period. Earlier research has already demonstrated that symptoms on continuous measures of psychological symptomatology increase with the number of traumatic deployment exposures, reflecting the accumulating risk in the ADF (Davy et al., 2012; Dobson et al., 2012; McFarlane et al., 2011b). Those findings also illustrate the substantial pool of subsyndromal disorder in populations of Regular ADF members who might continue to deploy, thus accumulating more symptoms on the basis of their exposure to further deployment and other traumas. This is a crucial aspect of the Impact of Combat Study and an important consideration for future long-term surveillance of the cohort.

Finally, the complex relationship between mental and physical health outcomes and combat-related trauma exposure is still not completely understood and is subject to a range of individual risk and protective factors that affect the development, exacerbation or remittance of mental health symptoms over time. For personnel deploying to high-risk combat zones, these factors can include other lifetime non-military traumas – particularly adverse childhood experiences such as child abuse and neglect (McGuinness & Waldrop, 2015) – and stressful life events experienced pre- and post-deployment, including such factors as financial stress and relationship difficulties (Steenkamp et al., 2017), all of which convey an additional risk for mental health disorders. Other studies have suggested that modifiable military organisational risk factors – such as low organisational commitment and low satisfaction with leadership – could also be important predictors of the mental health of combatants (Booth-Kewley et al., 2013).

The following sections look in greater detail at particular outcomes relating to the impact of combat, in both the short term and the longer term.

1.3 Deployment, combat and trauma

In the past 20 years there has been extensive research into the impact of deployment-related trauma exposure on the physical and mental health of military personnel. There is now strong evidence that the experience of traumatic exposures specifically – rather than deploying per se – is associated with adverse mental health outcomes (Crum-Cianflone et al., 2016; Seelig et al., 2012), although there are inconsistent findings relating to how deployment and combat exposure contribute to mental disorder. What is certain is that it is not only combat operations that can prove traumatic: any operational deployment, including peacekeeping or humanitarian assistance missions, can expose military personnel to experiences civilians rarely encounter.

The types of deployment traumas that can be experienced vary considerably. Standardised tools such as the Combat Experiences Scale (Hoge et al., 2004) have been developed to categorise and measure the type and frequency of traumatic events experienced during deployment to a combat zone (Fontana & Rosenheck, 1999; Hoge et al., 2004; Wilk et al., 2010). On the basis of previous research, a variety of traumatic deployment exposure categories have been identified; these include being in vulnerable situations, fear of events, coming under fire, being in danger of being killed, witnessing death or human degradation, seeing or handling dead bodies, and engaging in actions that result in death or injury. Despite it appearing that combat exposures may not convey any exceptional risk, it has been well established that trauma exposure – and, in particular, repeated or multiple trauma exposure (often experienced in the

military on combat operations) is associated with the development of psychological symptoms.

Moreover, research from the 2010 Mental Health Prevalence and Wellbeing Study (McFarlane et al., 2011b) has illustrated that, compared with demographically matched members of the wider Australian community, ADF members are significantly more likely to have experienced a greater number of various traumatic experiences in their lifetime, among them car accidents, life-threatening illness or injury and witnessing domestic violence (Searle et al., 2015; Van Hooff et al., 2011).

Similarly, recent research has found that up to half of PTSD cases in the UK military are not related to deployment at all (Jones et al., 2010). Together, these stressors, experienced in both their military careers and their personal lives, can place military personnel at heightened risk of developing a mental disorder.

1.4   Combat exposure and adverse mental health outcomes

Numerous international studies (mostly of US forces) have found an increased risk of probable mental disorder, including PTSD and depression, following combat and peacekeeping operations (Dlugosz et al., 1999; Hoge et al., 2004; Kang et al., 2003; Litz et al., 1997; Polusny et al., 2011a; Thoresen et al., 2003; Vasterling et al., 2010; Ward, 1997). More detailed analyses suggest, however, that it is the experience of trauma exposure while on deployment (for example, direct combat or witnessing atrocities) rather than simply deploying that is significantly associated with subsequent symptoms (Bartone et al., 1998; Fear et al. 2010; Hoge et al., 2006; Iversen et al., 2008; Sareen et al., 2007; Smith et al., 2008b). Furthermore, recent evidence suggests that previous civilian trauma such as witnessing or experiencing violence (Phillips et al., 2010), as well as other traumas or adversity experienced in childhood (Cabrera et al., 2007; Iversen et al., 2008; Van Voorhees et al., 2012), might increase the risk of PTSD and other mental health problems following exposure to deployment-related trauma.

Other studies of Canadian and US forces have reported a significant relationship between the number of pre-deployment life stressors and adverse childhood experiences and PTSD pre- and post-deployment (Cabrera et al., 2007; Nelson et al., 2011), with the impact of adverse childhood trauma outweighing any role of combat exposure. It appears, then, that it is cumulative trauma load – rather than combat or deployment exposures specifically – that is likely to be the critical driver of disorder development in military populations. Nevertheless, the high likelihood of traumatic exposures during deployment means that these exposures are a critical consideration in monitoring the health of military populations.

Interestingly, a large body of evidence now suggests that there is a high likelihood that disorder development will be delayed among veteran populations. For example, Horesh et al. (2011) reported delayed-onset PTSD in 1982 Lebanon war veterans, with a smaller delay observed in those with a greater number of trauma exposures – again consistent with a cumulative load model. Fikretoglu and Liu (2012) reported a similar pattern in Canadian troops: they proposed that the delay could stem from an inability to process the event while immersed in the combat environment as a result of active avoidance and emotional disengagement resulting from an inability to control repeated trauma exposures.

Another explanation for delayed-onset PTSD is the concept of sensitisation. As described earlier, 'sensitisation' refers to the progressively greater response to a stimulus with repeated or prolonged exposure. In this case, adaptive management of initial distress may be disrupted by subsequent stressors. Natural progression of the neurobiology underlying disorder development might also lead to the recruitment or manifestation of symptoms over time.

Also relevant to the concept of sensitisation is the consistent finding of the cumulative impact of trauma exposure on disorder development. Horesh et al. (2011) proposed that subsequent life events can trigger memories of a previous trauma, which in turn trigger posttraumatic symptoms relating to the previous trauma. Subsequent negative events can also have other consequences – that is, 'undermining … re-adjustment' (p. 864) – and these difficulties can lead to comorbidities. Consistent with a sensitisation hypothesis, Smid et al. (2013) found that increased post-deployment stressors were associated with the recruitment of symptoms over time among Dutch soldiers.

In summary, it is clear that repeated or prolonged exposure to trauma (as would be expected in a combat deployment role) through various mechanisms can be associated with poor psychological health, and it is likely to be the cumulative load of these exposures, rather than any single traumatic event, that is of central importance.

1.4.1   PTSD and other mental disorders

Combat exposure has been associated with a higher risk for PTSD and other mental health conditions in international militaries (Crum-Cianflone et al., 2016; Seal et al., 2009; Wisco et al., 2014) and remains a significant predictor of PTSD and other mental health disorders even after controlling for military and demographic variables, suggesting that combat exposure might convey specific risk. For example, a comparative study of the mental health outcomes of UK and US militaries showed higher prevalence rates of PTSD in US personnel compared with UK personnel. When self-reported combat exposure was controlled for, however, the differences in the prevalence of PTSD and other mental disorders no longer existed (Sundin et al., 2014). Connorton et al. (2011) analysed data from the US National Comorbidity Survey

Replication (n = 2383) to estimate whether combat, peacekeeping or relief work was associated with the prevalence of mental illness. They found that combat, alone or when combined with peacekeeping or relief work, was a risk factor for subsequent PTSD, as well as alcohol and substance use problems. Peacekeeping and relief work engaged in without combat exposure, however, were not associated with these diagnoses.

The 2016 Crum-Cianflone et al. study of the US Millenium Cohort (where 49% of the sample reported combat experience) found that participants who deployed and experienced combat, regardless of service branch or component, had the highest rates of PTSD, depression, and panic and anxiety symptoms. Furthermore, 12% of combat deployers in the study screened positive for any mental disorder at follow-up. The MEAO Prospective Study (Davy et al., 2012) used a longitudinal methodology to capture the course of symptoms over time by collecting data immediately before deployment (baseline) and then four months after deployment. This study found that operating in a combat role outside the main support base was associated with an increase in K10 psychological distress scores between pre- and post-deployment. Increases in psychological distress post-deployment were associated with a higher number of exposures and the type of traumatic deployment exposures experienced (Davy et al., 2012). Specifically, those who reported coming under fire, being exposed to vulnerable situations or fear of events, in danger of being killed or injured, being unable to respond to a threatening situation or experiencing human degradation had significantly greater increases in K10 psychological distress scores post-deployment compared with those who had not experienced these exposures (Davy et al., 2012).

It is likely that there is a complex interplay between PTSD and other mental and physical disorders, particularly in personnel who have experienced significant trauma. Significant rates of disorder comorbidity have been found in veteran populations – particularly for PTSD, depression and alcohol use. For example, the 2010 Mental Health Prevalence and Wellbeing Study found that over 30% of ADF members with a 12-month ICD-10 mental disorder (6.8% of the entire ADF) met criteria for two or more disorder classes (anxiety, affective or alcohol disorder) (McFarlane et al., 2011b). Comorbidity was particularly prevalent in those with an affective disorder: 64% of this group also met criteria for some other condition. This was consistent across the sexes and matched the patterns of comorbidity reported in the 2007 National Survey of Mental Health and Wellbeing (Teesson et al., 2009). Kehle et al. (2011) also examined rates of comorbidity in a sample of US National Guard soldiers returning from Iraq: 23% met criteria for one disorder, 10% reported two diagnoses, 3% met criteria for three diagnoses and 2% had four or more diagnoses. These results, together with the results of the 2010 Mental Health Prevalence and Wellbeing Study, suggest that higher rates of comorbidity may be observed in soldiers recently returning from deployment as a result of the substantial exposure to combat and other war-related traumas.

There is emerging literature to suggest that PTSD and alcohol misuse are significant problems among military personnel, especially veterans exposed to combat (Langdon et al., 2016). War-zone deployments and the subsequent mental health difficulties are strongly associated with an increased risk of alcohol misuse, which has been identified as a major problem for contemporary veterans of the Iraq and Afghanistan conflicts in US military populations (Burnett-Zeigler et al., 2011; Institute of Medicine, 2013; Seal et al., 2011) and internationally (Fear et al., 2007; Kelsall et al., 2015; Kimbrel et al., 2015; Thandi et al., 2015). Furthermore, alcohol and substance misuse disorders tend to co-occur with other mental health disorders in military populations (Norman et al., 2018; Boscarino et al., 2011).Thus, the co-occurrence of alcohol misuse and mental health disorders means that alcohol misuse is often diagnosed as 'dual disorder' (most frequently with PTSD and depressive disorders) and has been associated with adverse outcomes in combat-exposed veterans (Heltemes et al., 2014).

A systematic review of studies of US military service members and veterans (Cohen et al. 2015) revealed that deployment with combat exposure was a consistent predictor of alcohol misuse. Another study found higher prevalence rates of alcohol use disorder in female clients of the US Department of Veterans Affairs who had experienced combat (41%) (Hoggatt et al., 2015). Similarly, an analysis of the US Millenium Cohort found separation from military service and exposure to combat while deployed were risk factors for a relapse into problem drinking (Williams et al., 2015).

Although there has been limited research into how combat exposure is related to problematic drug and alcohol use in veteran populations, it has been suggested that veterans might use substances to 'blunt' mental health symptoms associated with trauma exposure. There is good evidence to support this, changing patterns of alcohol consumption being a marker of PTSD risk (Crum et al., 2013; Kline et al., 2014). Alcohol use in these circumstances represents a pattern of consumption to self-medicate to counteract the distress associated with the symptoms of PTSD (Jacobsen et al., 2001).

In addition to combat-related trauma, exposure to childhood trauma (Danielson et al., 2009) and pre-deployment mental health symptoms (Jacobson et al., 2008) are associated with alcohol use (Kelley et al., 2015). This relationship differs somewhat between men and women and appears to be mediated by other comorbid mental health conditions, particularly depression (Kelley et al., 2013, 2015). The notion of the use of alcohol for self-medication purposes is also supported by recent studies of US deployed personnel, which have reported an association between alcohol misuse and alcohol-related behavioural problems following combat exposure and the experience of war-zone stressors in Iraq (Thomas, 2010; Wilk et al., 2010).

Anger is increasingly recognised as a common feature of posttraumatic stress (Barrett et al., 2013), such that it is now formally acknowledged in the *Diagnostic and Statistical Manual, Fifth Edition* PTSD criteria (Friedman et al., 2011). It can be associated with the increased arousal that is frequent in posttraumatic stress and also with the exaggerated vigilance that can trigger aggression in response to perceived threats (Jakupcak et al., 2007). Moreover, anger can be a major driver of poor functioning because of its capacity to disrupt social interactions and close interpersonal relationships (Meffert et al., 2014). In the context of this present report, anger is of interest both as a symptom in its own right and as a potential marker of subsyndromal distress and dysregulation.

Finally, these psychological disorders are often comorbid with physical health conditions such as cardiovascular disease, diabetes and metabolic syndrome. For example, Kelsall et al. (2015) found that 3.7% of Australian Gulf War veterans reported comorbid musculoskeletal disorder and psychological disorder (depression, PTSD), and this was more common in Gulf War veterans compared with a sample of military veterans who had not been to the Gulf War. In addition, mental health and wellbeing were worse in those with comorbid PTSD and/or depression and musculoskeletal disorder than in those with musculoskeletal disorder alone, highlighting the additive impact of comorbid disorder on overall mental health.

The relationships between mental and physical conditions could be important for understanding pathways to disorder development, particularly when the onset of symptoms is delayed. Recently researchers have been focusing on the role of systemic bodily processes that might underlie the development of both psychological and physical disorders. In relation to comorbidity, conditions such as metabolic syndrome and cardiovascular disease could share pathways with comorbid psychological conditions such as PTSD and depression (Turner et al., 2013; von Kanel et al., 2007).

1.4.2   Suicidality

An increase in the prevalence of suicide attempts has been reported in connection with many militaries in the past decade, and considerable attention has been given to the course of and risk for suicidality (Schoenbaum et al., 2014). A multitude of factors have been linked with suicidal thoughts and plans in military populations, some of the more common being female gender (although the risk of completed suicides is higher in males), people at early stages of their careers, and co-existing mental and physical health conditions (Ursano et al., 2016). Although deployment in isolation does not seem to be the determining risk factor for suicidality, individual deployment-related traumatic events may influence risk, and longitudinal work suggests that among those with at least one previous deployment, the risk for suicide attempts was higher in those with either PTSD or depression after return from deployment and particularly at the six-month post-deployment mark (Ursano et al., 2016).

A very high level of suicidality was documented in the *Mental Health Prevalence Report,* in Transitioned ADF members in particular and among individuals serving in the Regular ADF (Van Hooff et al., 2018). As discussed in that report, the level was dramatically higher than the rates documented in the MHPWS. The reasons for the increase are not entirely clear, although suicidality also commonly accompanies other mental disorders and symptoms (Beautrais et al., 1996; Krysinska & Lester, 2010), and increases in suicidal ideation can be reflective of increased rates of disorder and distress in a population.

1.5   Combat exposure and adverse physical health outcomes

Despite a focus on psychological health following trauma and stress exposure, physical health outcomes are also important. Studies in military and non-military populations have demonstrated associations between trauma exposure and physical health consequences such as altered neuroendocrine and immune function (Boscarino & Chang, 1999) and conditions such as rheumatoid arthritis (Boscarino et al., 2010), diabetes and cardiovascular disease (Pietrzak et al., 2011). Importantly, while there are high levels of comorbidity between these and psychological disorders such as PTSD and depression (Kelsall et al., 2009), these associations may also be independent of psychological health outcomes (Sledjeski et al., 2008). The physical health consequences of deployment are particularly relevant when considering evidence of somatisation of psychological symptoms in some subgroups (Bryan et al., 2014). Furthermore, it has been argued that highly trained military personnel might be more likely to manifest physical responses to stress by virtue of training components that are designed to suppress emotional reactivity (Killgore et al., 2006).

Combat exposure specifically has been linked to a number of adverse physical health conditions and non-specific medically unexplained somatic complaints related to psychological combat traumas (McFarlane et al., 1994). Post-deployment somatic distress has been well described in the literature and was initially seen in Gulf War veterans who reported elevated levels of medically unexplained somatic symptoms. This constellation of somatic complaints subsequently came to be known as 'Gulf War Syndrome', although its existence as a syndrome was vigorously debated (Kelsall et al., 2014a; Unwin et al., 1999; Iowa Persian Gulf Study Group, 1997).

In addition to non-specific somatic symptoms, among the physical health conditions commonly identified in veteran populations are musculoskeletal disorders, fatigue, hypertension, metabolic syndrome, hyperlipidemia and cardiovascular disease – see McFarlane (2010b) for a review. All of these physical health conditions have significant associations with emerging mental disorders, including PTSD and depression (Abouzeid et al., 2012; Kelsall et al., 2014b), and the comorbidity of physical symptoms and psychopathology, particularly PTSD (Hoge et al., 2007), is of interest in veteran

populations. How physical and psychological symptoms manifest over time and their connections with each other are also of central relevance to the topic of cumulative trauma burden and sensitisation.

1.6   Cumulative trauma and its role in pathways to disease

The impact of cumulative trauma on biological mechanisms, and their role in manifesting physical and mental illness is an area of intense interest in military research. There is now substantial evidence suggesting that repeated traumatic exposures over a prolonged period can increase the risk of morbidity and even mortality (Boscarino, 2006; Holdeman, 2009; Johnson et al., 2004; McFarlane, 2010b). This is particularly relevant to military personnel, who often experience multiple trauma exposures through combat. This interwoven relationship is not yet properly understood, but the literature suggests there are a number of common and shared underlying neurobiological mechanisms associated with physical and somatic manifestations of disease (McFarlane, 2010a, 2010b).

One plausible hypothesis as to why somatic symptoms are a substantial consequence of combat exposure is that physiological arousal in high-threat situations might facilitate long-term dysregulation of physical homeostasis. The human body has a number of finely regulated systems that respond to stressors in the environment in an effort to maintain homeostasis. Maintenance of homeostasis in the face of stressors has been termed 'allostasis' (McEwen, 1998). Among the bodily systems involved in the maintenance of stability are the nervous, immune, metabolic and cardiovascular systems. The immune system plays a particularly important role in relation to stress exposure and has relevance to psychological and physical outcomes of stress (McEwen, 1998, 2000). The nervous system regulates how the body adapts to stress and is involved in neuroendocrine responses via the HPA axis, which, among other things, regulates the release of cortisol and adrenaline, these being involved in fight and flight responses (Juster et al., 2010). The HPA axis is the body's primary stress management system and responses here affect the immune, metabolic and cardiovascular systems. In relation to the immune system specifically, inflammatory proteins secreted by cells, such as t-cell lymphocytes and macrophages, stimulate cortisol secretion. Glucocorticoid receptors are also involved in the suppression of inflammatory responses (Cohen et al., 2012).

1.7   Neurocognitive function

As discussed, there is now compelling evidence to support the notion that trauma and stress might affect mental and physical health via a range of neurobiological mechanisms. In the case of neurocognitive measures of brain function, numerous cross-sectional investigations have examined these in relation to mental health and

disorders and have provided insights into the processes underlying psychological symptom development and the neural profiles of existing psychopathologies. Further, emerging evidence suggests that prospective quantitative electroencephalography (qEEG) assessments might also hold predictive value in relation to the onset of future psychiatric symptoms (Blackhart et al., 2006). These qEEG methods might thus prove a useful tool in the prediction and monitoring of long-term mental health, particularly in high-risk populations such as military personnel.

In addition to their potential value for early identification of risk, neurocognitive indices are important for understanding possible functional impairments that can be associated with mental disorders. In military populations in particular, where delayed onset of disorders is more common, and in the case of the Transition and Wellbeing Research Programme – where a distinct increase in disorders has been found among ADF members when they transition from full-time regular service (Van Hooff et al., 2018) – the ability to identify risk and early impairment before the emergence of a diagnosable disorder is especially important.

In the case of neurocognitive function in particular, while behavioural outputs might show little or no disruption the underlying processing can be significantly impaired. This has implications for sustaining health in the face of the additional cognitive load required to maintain functional ability, especially when a population is likely to be redeployed. Importantly, numerous novel techniques are now being trialled to aid improvements or changes to underlying cognitive function (Sitaram et al., 2017; Vernon, 2005). Many are still in the trial phase, but they do represent real possibilities for risk mitigation and early intervention. In the current investigation a range measures of underlying cognitive function were captured. For the purposes of this report, two were focused on – resting qEEG and event-related potential measures of working memory function.

1.7.1   Quantitative electroencephalography

qEEG is a method for measuring brain electrical activity; it involves high-powered computer analytic systems deconstructing signals from multi-channel EEG into power frequency spectra (Kropotov, 2010). Spectral analysis of qEEG has been used to define a set of basic EEG rhythms that are associated with certain physiological and functional states. In general terms, four primary spectral wavebands are extracted from EEG recordings – beta, alpha, theta and delta frequencies.

Beta waves, which are high frequency and have been associated with cortical excitability, tend to be found predominantly in frontal or central regions of the brain. Beta power increases with the level of brain activation. Studies have found a positive correlation between beta power and underlying cortical metabolism, supporting the suggestion that this frequency band is associated with increased cortical activity. Alpha

rhythms tend to predominate in posterior regions (the occipital and parietal areas), in primary and secondary sensory areas of the brain. During quiet wakefulness, the alpha rhythm is generally associated with a resting or idle state of consciousness and decreases with the level of brain activation (Kropotov, 2010). Alpha peak frequency also reflects working memory capacity. Theta rhythms are considered slow wave and are commonly observed in deep relaxation or sleep. In wakeful EEG recordings, however, theta power has been found to be associated with attentional and memory processes, including encoding and retrieval. Delta is the slowest waveband, with the highest amplitudes in the spectrum; it is commonly observed in deep sleep and is not generally prominent during cognitive activity (Kropotov, 2010).

There have been significant gains in identifying the specific electrophysiological profiles of various psychopathologies in recent years, and more than 80% of clinically diagnosed individuals have been shown to exhibit some form of qEEG abnormality (Coutin-Churchman et al., 2003). As a result, qEEG methods might eventually identify objective neural markers for common psychiatric disorders. Some inconsistency exists, but cross-sectional research has identified beta, alpha and theta power elevations as potential markers of clinical depression (Begić et al., 2011; Knott et al., 2001; Nystrom et al., 1986; Pollock & Schneider, 1990). Elevated beta and theta power have also been implicated in the neurophysiology of anxiety disorders such as social phobia (Sachs et al., 2004a), panic disorder (Knott et al., 1996) and PTSD (Begić et al., 2001; Jokić-Begić et al., 2003).

In the MEAO Prospective Study (Davy et al., 2012) the general pattern of findings suggested that initial deployment and combat exposure could have lasting impacts on resting brain states. There was some evidence to suggest that these impacts could also have flow-on effects in relation to subsequent deployments (a sensitising effect). The number of previous deployments and total months deployed in the preceding three years were associated with reduced occipital alpha-2 power (eyes closed) post-deployment. There was a particularly marked post-deployment reduction in participants who had no previous deployment experience. These findings suggest cortical hyperarousal as a consequence of deployment (Veltmeyer et al., 2006). The amount of time spent on the most recent deployment was associated with increased frontal theta power, suggesting disruption of working memory function. Previous combat exposure was associated with increased frontal and increased centroparietal alpha (eyes open) and reduced beta in frontal, central and centroparietal regions. These findings are further suggestive of diminished attentional processing capacity.

1.7.2 Working memory

Another electrophysiological measure of cognitive function, event-related potential, or ERP, is an extension of electroencephalography. It measures brief (sub-second) fluctuations in electrical brain activity, these being directly associated with specific sensory and cognitive processing events. One component of ERP, the P300 or P3, provides a physiological measure associated with attentional and working memory operations during cognitive tasks (Polich, 2007). This component is commonly assessed during attention or executive memory tests such as the oddball task (Squires et al., 1975), as well as the n-back working memory task (see Owen et al., 2005) used in the present study. Although the P3 component is observable across many brain regions, evidence suggests that more anterior (frontal and central) amplitudes reflect processes involved in automatic attentional orientation, whereas more posterior (parietal) amplitudes reflect processes involved in higher order executive memory function. In broad terms, lower P3 amplitudes are shown to be associated with deficits of attention and/or memory, whereas higher amplitudes are conversely associated with superior cognitive function (Luck & Kappenman, 2011), although there are some exceptions to this generalisation.

Working memory has been described in a variety of ways, but prevailing models tend to consider it as a limited-capacity cognitive system, used for the temporary storage and manipulation of information over a relatively short period. These processes are considered essential to subserve higher order executive functions such as planning, problem solving, comprehension and reasoning (Baddeley, 2000; Clark, 1998; Owen et al., 2005).

Working memory is of particular interest in military populations because military-specific factors such as deployment have been found to be associated with deficits in areas of cognitive functioning (Johnson & Magaro, 1987). Among these areas are sustained attention, verbal learning and visual–spatial memory – processes that are all subserved by working memory. Disturbances in cognitive function are also associated with a range of psychiatric disorders that tend to be prevalent in military populations, including depression, panic disorder, generalised anxiety disorder and PTSD (Castaneda et al., 2008; Rose & Ebmeier, 2006). Working memory can also be compromised in people who have suffered a mild traumatic brain injury (Keightley et al., 2014). Significantly, even in the absence of any psychiatric disorder, there is evidence that experiences such as military deployment have the potential to disrupt information processing (Naatanen, 1995).

Because disturbances in attention and memory are characteristic of a range of psychiatric disorders (Millan et al., 2012), the P3 component has been widely examined as an index of cognitive dysfunctions in clinical populations. There are some inconsistencies, but the majority of cross-sectional studies examining ERP data have

reported reduced P3 amplitudes (both anterior and posterior) in clinical depression groups when compared with healthy control groups – see Luck & Kappenman (2011) and Johnson et al. (2013) for a review. Notably, more pronounced amplitude reductions have also been reported in depression groups with melancholic features (Ancy et al., 1996) as well as groups at higher suicide risk (Hansenne et al., 1996). The P3 component thus appears to be a viable marker of cognitive dysfunction, clinical characteristics and possibly symptom severity in groups exhibiting depression symptomatology.

The P3 component has not been as rigorously investigated in relation to anxiety disorders, but studies examining social phobia (Sachs et al., 2004b), as well as anxiety-related somatoform disorder (Berryman et al., 2017), have reported diminished P3 amplitudes similar to those observed in clinical depression. Interestingly, panic disorder appears to be an exception in anxiety-disordered populations: some studies have reported *elevated* P3 amplitudes, particularly in the fronto-central brain regions (Clark et al., 1996; Iwanami et al., 1997). Importantly, while higher P3 amplitudes are most commonly associated with superior cognitive functions, it has been suggested that these amplitude elevations in panic-disordered groups reflect attentional hypervigilance.

Although inference in relation to developmental chronology remains limited as a result of cross-sectional methodologies in previous research, a monozygotic twin study by Metzger et al. (2009) provided evidence that P3 reductions associated with executive memory impairments are an acquired characteristic in combat-related PTSD. Although the effects of military deployment on ERP indices have not been widely examined, a prospective neuropsychological investigation by Vasterling et al. (2006b) provided evidence that military personnel exhibit deficits of attentional and executive function following recent deployment. Further, van Wingen et al. (2011) evaluated the neural consequences of severe stress exposure in a group of healthy soldiers and found that prolonged exposures to trauma and stress, as experienced in a combat environment, increased the amygdala insula reactivity to stimuli, resulting in sustained vigilance. It remains unclear, however, whether these acquired deficits have an enduring impact on cognitive function or future mental health outcomes, or both. The ERP investigation in the current study might thus assist in clarifying the effects of deployment on cognitive function, as well as potential associations with these longer term outcomes.

1.8   Traumatic brain injury

In relation to deployment, combat exposure and blast injury in particular, the question of traumatic brain injury is of great interest. As well as the more immediate physiological and psychological costs of TBI, there is also interest in the potential longer term consequences. Because of the nature of TBI, assessing prevalence

accurately is difficult and in many cases not possible. There is, however, much emerging evidence that repeated exposure to even mild TBI (mTBI) could place individuals at risk of physical and psychological morbidity in the future (Pietrzak et al., 2014).

The US Department of Defense reported that as of February 2018 a total of 379,519 US service members had been diagnosed with TBI of all severities worldwide (that is, first-time medical diagnoses of TBI that occurred anywhere US forces were located, including in the United States, between 2000 and 2017). Of these, 82.3% were classified as mTBI – often referred to as concussion. These injury numbers increased from about 11,000 US service members diagnosed in 2010 to a peak of 32,800 diagnosed in 2011 and have since steadily declined each year, to 17,700 diagnosed in 2017. The greatest incidence was documented in the Army (Department of Defense and Veterans Brain Injury Centre, 2018) and blast exposure was the most frequently cited mechanism of injury.

1.8.1 Definition of mild traumatic brain injury

In 2004 the WHO Collaborating Centre Task Force defined mTBI thus:

> An acute brain injury resulting from mechanical energy to the head from external physical forces. Operational criteria for clinical identification include: (i) 1 or more of the following: confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and/or other transient neurological abnormalities such as focal signs, seizure, and intracranial lesion not requiring surgery; (ii) Glasgow Coma Scale score of 13–15 after 30 minutes post-injury or later upon presentation for healthcare. These manifestations of MTBI must not be due to drugs, alcohol, medications, caused by other injuries or treatment for other injuries (e.g. systemic injuries, facial injuries or intubation), caused by other problems (e.g. psychological trauma, language barrier or coexisting medical conditions) or caused by penetrating craniocerebral injury. (Carroll et al., 2004a, 2004b)

Although there are numerous definitions of mTBI in the literature, many with overlapping criteria, there are also major differences between definitions (Kristman et al., 2014) and methodologies. Standard criteria for defining mTBI would improve the comparability of studies, but they do not exist at present, which means the criteria used for measuring and defining mTBI should be clearly disclosed in any research in this area (Kristman et al., 2014).

A 2011 report outlined three major methodological challenges in the measurement of mTBI that should be considered (McFarlane et al., 2011a). First, although mTBI screening measures should be identical, based on the definitions just mentioned, they do vary from study to study and thus affect the prevalence rates measured. Second, screening measures are not diagnostic tools, so caution must be used in attributing a symptom to mTBI before ruling out other possible causes. Third, studies often rely on

retrospective self-reporting of events involving loss of consciousness, awareness and memory, and recall is not always reliable. Polusny et al (2011b) found that at T1 (one month before returning home from deployment) 9.2% of participants reported deployment-related mTBI, whereas at T2 (one year later) 22% of participants self-reported mTBI. Similarly, more recently Alosco et al. (2016) used in-person interviews at post-deployment and phone interviews five to nine years later to assess temporal consistency of TBI endorsement for an index deployment to Iraq; they found that deployment-related TBI might not be reported reliably over time, particularly among those with greater PTSD symptoms (Alosco et al., 2016). (See Annex D for a more detailed discussion of this subject and the associated methodological difficulties.)

1.8.2   Prevalence of mild traumatic brain injury

Prevalence estimates for mTBI in military populations are difficult to determine and vary from country to country, partly because of differing definitions and partly because of methodological differences. The MEAO Prospective Study (Davy et al., 2012) was the first epidemiological study to investigate mTBI in a serving Australian military population, using a self-report screening tool used in other international military research (Hoge et al., 2008). The study found 26.9% of participants self-reported meeting the criteria for lifetime mTBI at pre-deployment and 9.3% for a new mTBI at post-deployment (Davy et al., 2012). These rates are somewhat consistent with the international literature, although studies in US military populations have generally reported higher prevalence estimates than studies of UK or Canadian military populations. Furthermore, the vast majority of studies have been done in the United States, with the widely cited Hoge et al. (2008) reporting an mTBI prevalence of 15.2% in their sample of US soldiers who had deployed to Iraq. Even within US military populations, however, reported prevalence rates vary from 12% to 20% (Hoge et al., 2008; Wilk et al., 2012). A more recent study of US soldiers returning from deployment in Iraq or Afghanistan reported that just 9% screened positive for a probable deployment-related mTBI using the Ohio State University Traumatic Brain Injury Identification Method (Schwab et al., 2017) – a figure similar to that found in the Australian MEAO Prospective Study sample (Davy et al., 2012).

In contrast to the US prevalence studies, a study by Rona et al. (2012b) of UK military personnel deployed to Iraq and Afghanistan reported a much lower prevalence of mTBI of 4.4%. A more recent study in Canadian military personnel deployed to Afghanistan from 2009 to 2012 reported a similar prevalence of mTBI, at 5.22% (Garber et al., 2016). There are a number of possible explanations for these estimates being lower than those reported in studies of US military personnel. The degree of combat exposure is an important factor influencing mTBI prevalence estimates. In fact, Rona et al. (2012a) found that the prevalence of mTBI increased from 4.4% to 9.5% when the sample was limited to those in combat roles on deployment. In addition, they found an association between the length of deployment and mTBI. The mTBI prevalence

estimate of 4.4% increased to 9.0% per 100 person-years as an estimated incidence for the UK armed forces when deployment length was taken into account. The estimate increased further, to 10.2% per 100 person-years, when only groups with higher potential for blast exposure (Royal Marines and Army participants) were included. Since US deployments are in general longer than those of British military personnel, it was considered that this could contribute to the higher prevalence of mTBI reported in US studies. It was recommended that comparisons of mTBI rates, when based on last deployment, take into account the length of deployment (Rona et al., 2012a). Cultural differences as well as access to health care might also play a role and contribute to the differences in mTBI rates reported for various countries (McFarlane et al., 2011a; Rona et al., 2012a).

1.8.3   Post-concussive symptoms and cognitive deficits

The term 'mTBI' refers to an event in which the head is physically injured; the condition is identified according to a range of characteristics, as described in Annex D. mTBI can result in ongoing functional problems, such as emotional, cognitive and behavioural disturbances (Lagarde et al., 2014), which are collectively referred to as 'post-concussive symptoms'. PCS are characterised by 'headache, dizziness, irascibility, inordinate fatigue on effort, intolerance to intoxicants and vasomotor instability' following a blow to the head (Strauss & Savitsky, 1934). This historical definition is reflected in current operational definitions of PCS, including those of the International Classification of Diseases 10th Revision (ICD-10) (World Health Organization, 1993) and the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (American Psychiatric Association, 1994). PCS are those symptoms that can occur in the days or weeks following the injury event and include problems with memory, balance, sleep and concentration; headache; tinnitus; sensitivity to light or other visual disturbance; fatigue and irritability (Bryant, 2008; Fear et al., 2009). They are referred to as persistent post-concussive symptoms if they continue beyond 'normal' recovery periods (McFarlane et al., 2011a).

A Canadian study of personnel deployed to Afghanistan from 2009 to 2012 found that multiple PCS were reported in post-deployment screening in 21% of cases of less severe mTBI and in 27% of more severe cases of mTBI. These proportions were similar to the proportions reporting PCS (15–35%) in previous US post-deployment military studies (Garber et al., 2014). Studies conducted in civilian populations, particularly sports injury populations, have found that the symptoms resolve completely in days to weeks in the majority of cases (Carroll et al., 2004b). A systematic review of the prognosis of mTBI in civilian populations in 2004 found that PCS are mainly resolved within two to three months of the injury, and where deficits in these areas were present the determinants appeared to be related to personal and social factors, rather than the mTBI itself. A 2014 systematic review of mTBI in civilian populations found that the condition was associated with cognitive deficits between 48 hours and two

weeks after injury, although the reviewers noted that consistency in the tests administered was poor and the exact deficits and their magnitude varied for the studies (Carroll et al., 2014). Some individuals affected by mTBI continue to report difficulties weeks or months later; estimates of those with persisting symptoms have been as high as 20%, but more comprehensive reviews of recovery post-mTBI in civilian populations report that less than 5% is likely a more accurate figure (Carroll et al., 2004b; McCrea et al., 2009; McFarlane et al., 2011a). Schwab et al. (2017) conducted a US cohort study of veterans returning from Iraq and Afghanistan between 2009 and 2014 and reported that nearly half (47%) of those who had sustained an mTBI reported one or more severe or very severe PCS at three months post-deployment; this compared with 25% of controls (Schwab et al., 2017). In addition to differences between countries, several other factors contribute to the difficulty in establishing accurate prevalence rates of PCS. Among these are post-concussive symptoms' highly non-specific nature, their overlap with symptoms of common mental disorders, and their well-established association with other mental health problems and comorbidities. Annex D provides further detail on this.

In summary, although there has been extensive research into traumatic brain injury in military samples, there are a number of difficulties associated with accurately determining prevalence rates and with assessing TBI more generally. Where diagnosed or probable TBI is present, there is evidence of associations with a range of psychological, physical and functional impairments. Whether these associations reflect underlying cortical pathology or are related in a more indirect way, reflecting psychological and physical consequences of the traumatic experience potentially surrounding the injury mechanism, is, however, not clearly understood.

1.8.4   Neuroimaging evidence

Traumatic brain injury can be understood as a transfer of mechanical energy into the brain from an external traumatic event such as rapid acceleration or deceleration, a direct impact to the head or an explosive blast. This can cause structural, physiological, and/or functional changes in the brain that can lead to neurological, cognitive and behavioural symptoms, which may be long lasting (Jeter et al., 2013; Oehr & Anderson, 2017). For this reason, many studies have investigated how mild traumatic brain injuries affect brain structure and functioning. One of the reasons for exploring the potential impacts of mTBI on neural functioning among deployed ADF personnel is concern that exposure to combat, and particularly experiencing an mTBI, could predispose personnel to greater risk of dementia in later years. This possibility arises from increasing evidence that TBI can contribute to an earlier onset of dementia (Mendez, 2017).

Structural deficits associated with TBI

There is considerable variability in the evidence on structural deficits in TBI patients. One recent review summarised five studies of mTBI and reported decreased cortical thickness and decreased thalamus and amygdala volumes (Mu et al., 2017). Further, these changes have been associated with functional outcomes. For example, one study of 76 military personnel who sustained mTBIs found abnormal thickness in the right thalamus and globus pallidus relative to injured controls, and these were related to symptom measures (Bolzenius et al., 2018). It should be noted that any structural changes following mTBI are dynamic over time: there is evidence that cortical abnormalities in the days after such an injury differ from how the abnormalities present several months later (Wang et al., 2015). Moreover, there appears to be overlap between observed structural changes after mTBI and the effects associated with posttraumatic stress, which also accounts for cognitive and emotional sequelae of mTBI (Lopez et al., 2017). Overall, there is increasing recognition that the subtle effects of mTBI are more accurately detected by imaging techniques that focus on microstructural changes, including white matter integrity (Shin et al., 2017).

Structural deficits associated with PTSD

Many studies have examined brain structure in PTSD, and these have strongly converged with consistent, robust findings. Rather than review individual studies here, it is more informative to consider some of the large systematic reviews of the available evidence. Several meta-analyses of the available studies have highlighted two important regions that are abnormal in people with PTSD relative to healthy controls and trauma-exposed controls without PTSD. One meta-analysis of 44 studies found that PTSD was associated with a reduced volume of the hippocampus and anterior cingulate (O'Doherty et al., 2015); another, a meta-analysis of 20 studies, also found that PTSD was characterised by a smaller left insula and right parahippocampus (Meng et al., 2014).

White matter deficits associated with TBI

Many studies have been conducted in order to determine white matter integrity in survivors of TBI because the integrity of these tracts can affect cognitive functioning. One meta-analysis of 20 studies of people affected by TBI found that memory and/or attention were very strongly related to diffusion tensor imaging findings in the corpus callosum, fornix, internal capsule, and arcuate and uncinate fasciculi (Wallace et al., 2018).

These tracts have been noted to be affected in military samples who have sustained mTBIs (Eierud et al., 2014). In the context of being exposed to IEDs in recent conflicts in the Middle East, numerous studies have focused on the effects of blast injuries on white matter integrity. One recent meta-analysis found that, despite the considerable variation in studies, eight of 18 studies identified deficits in integrity in the corpus

callosum and superior longitudinal fascilicus (Mu et al., 2017). One large study of US military personnel found that among 834 deployed personnel who sustained an mTBI, there was evidence of a greater incidence of white matter hyperintense areas, as well as pituitary abnormalities (Riedy et al., 2015).

Several studies have noted that post-concussive symptoms can be associated with white matter compromise in mTBI patients (Bartnik-Olson et al., 2014; Messé et al., 2012). For example, PCS have been associated with microstructural compromise in the uncinate fasciculus, the inferior fronto-occipital fasciculus, the internal capsule and the corpus callosum, as well as in the parietal and frontal subcortical white matter (Smits et al., 2011). Further, cognitive deficits associated with mTBI have been associated with diffuse axonal injury in the anterior corona radiata, the uncinate fasciculus, the inferior longitudinal fasciculus, cingulum bundle and the genu of the corpus callosum (Costanzo et al., 2014; Niogi et al., 2008). Importantly, improvement in PCS severity has also been found to be associated with reductions in white matter abnormality (Ling et al., 2012). In contrast, though, another study of combat veterans found no association between white matter integrity and PCS (Petrie et al., 2014).

White matter deficits associated with PTSD

In connection with PTSD, there is evidence of microstructural white matter changes within the cingulum, uncinate fasciculus and corpus callosum (Abe et al., 2006; Aschbacher et al., 2017; Costanzo et al., 2016; Daniels et al., 2013; Jackowski et al., 2008; Sekiguchi et al., 2014), although other studies have found no white matter abnormalities (Jorge et al., 2012; Morey et al., 2013; Taber et al., 2015). In terms of the impact of PTSD on white matter microstructure in mTBI, one longitudinal study found that patients who developed PTSD six months after an mTBI event exhibited abnormal white matter characteristics relative to those who did not develop PTSD and healthy controls during both sub-acute and chronic stages following mTBI. Patients who did not develop PTSD were distinct relative to controls only during the acute phase, yet demonstrated recovery in white matter after 20 days (Li et al., 2016). Another study found that, after controlling for PTSD symptoms, white matter abnormalities in mTBI patients were associated with physical, but not emotional or cognitive, PCS symptoms (Miller et al., 2016).

In all, there is compelling evidence of various consistent structural differences and white matter deficits in the brain associated with blast exposure, TBI and PTSD. Neuroimaging techniques that allow the visualisation of brain structure and white matter integrity have utility in the detailed examination of blast exposure and TBI and so are incorporated in the current study as a pilot examination.

1.9 Summary

International and Australian evidence indicates that deployment and associated combat exposure are likely to have long-term psychological and physical costs for at least some individuals. Because members of the cohort examined for the present study were exceptionally healthy at the time they were initially recruited into the MEAO Prospective Study, it was expected that the great majority would remain so at this follow-up, although it was expected that there would be symptom increases. Recruitment of symptoms with the passage of time does not occur in a linear fashion and may be influenced by myriad demographics (for example, age) and service and non–service related factors. In at-risk groups, while symptoms and disorder may be expected to fluctuate with time as individuals move in and out of subsyndromal and diagnosable disorder states, these fluctuations will likely occur on an upward trajectory. As a result, in the present study we expected to see a pattern of increasing mental and physical health symptoms and disorder over time, with particular subgroups at greater risk of moving into subsyndromal and disorder states.

It is certainly clear from the literature that cumulative exposure to traumatic stressors increases the risk of symptom recruitment and disorder emergence over time, so it is expected that those with the greatest deployment and combat exposures will also have the greatest risk of symptom increases with time. Findings from the *Mental Health Prevalence Report* demonstrated that much of the risk of symptom and disorder development lies within the subset of ADF members who have transitioned from regular service (Van Hooff et al., 2018). This is in part a result of the fact that mental disorder can be a precursor to transition but perhaps also a result of the experience of transition itself exacerbating symptom development. As discussed, there is clear evidence that in the case of mental disorder current life stressors exacerbate symptoms and are associated with an increased risk of disorder among previously deployed military personnel. Evidence from other research, findings from the earlier MEAO Prospective Study and findings from the other studies in the Transition and Wellbeing Research Programme suggest it is likely that, with time, increasing psychological and physical manifestations of distress will have emerged in this cohort.

In addition to documenting self-reported health outcomes over time for the cohort, data on a number of unique objective measures of biological and neurocognitive function were collected, allowing time-dependent changes, effects of deployment and combat exposures, and mechanistic factors relating to the question of sensitisation to be explored. A focused and exploratory investigation of injuries to the head, TBI, and self-reported and objective structural and functional neural correlates in this cohort is also included, with a view to determining optimal directions for research in this area in future.

1.10   Structure and interpretation of this report

This report first summarises the response rates and demographic characteristics of the Combat Study cohort. It then describes the mental, physical and biological health of the cohort over time, including how it has changed. This is followed by an examination of the current mental health status of the cohort and how various service- and deployment-related factors predict this. The report then documents the neurocognitive function of a subset of the cohort over time, again exploring how this relates to current mental health status. Chapter 7 focuses specifically on traumatic brain injury, providing an overview of the prevalence of TBI in this population, a limited examination of associations between TBI and mental health and functioning, and a summary of the pilot neuroimaging investigation. The report concludes with a synthesis of the findings, discussion and implications.

It is the health of a single cohort that is documented, and all data are unweighted. Where possible changes over time and between-group differences are statistically tested. Because of the limited size of some subsamples in the cohort, however, only descriptive results are presented in some sections.

1.11   Aims, objectives and scope of the current report

The primary purpose of the Impact of Combat Study was to follow up on the mental, physical and neurocognitive health and wellbeing of participants who deployed to the Middle East Area of Operations between 2010 and 2012. The study thus had two main aims:

- To detect early shifts in and the emergence of illness, so that these can be targeted in treatment and prevention strategies. In the early stages of illness physiological systems are far more amenable to reregulation compared with when complications and chronic manifestations of illness become observable. It is therefore important to detect subsyndromal change and mild illness as early as possible.

- To document the prevalence of TBI and associated comorbidities through an examination of deployment, combat exposure and exposure to blast injury and a pilot neuroimaging study of combat troops with exposure to blast and other deployment-related traumas.

This report addresses these aims in the following key objectives:

1. To investigate the longitudinal course of mental disorder in ADF members deployed to the MEAO between June 2010 and June 2012.

2. To characterise both the deployment and non-deployment risk factors associated with poor longitudinal mental health outcomes following deployment to the MEAO. This will include an investigation of the role of combat exposure in the development of disorder over time.

3. To examine the long-term trajectory for resilient ADF members following deployment to the MEAO.

4. To examine the interaction between pre-deployment trauma and deployment-related trauma on longitudinal mental and physical health outcomes of MEAO-deployed Defence members.

5. To investigate deployment-related mild traumatic brain injury.

To address these objectives, the report examines the following:

- the long-term physical and psychological health consequences of deployment-related traumatic exposure

- the psychological, physical and neurocognitive health consequences of combat exposure

- the prevalence of mild traumatic brain injury (mTBI) in the study cohort, and additional data obtained from magnetic resonance imaging, to verify

  – the presence (or absence) or neural injury or damage

  – whether measurable cognitive deficits and psychological symptoms reflect cortical changes.

Interpreting and discussing the findings

Rates of disorder. Except where otherwise specified all analyses were conducted using raw totals, means and proportions, with no statistical weighting used. Except where otherwise specified, standard errors were produced using linearisation.

Confidence intervals. Confidence intervals express the degree of uncertainty associated with a sample statistic. Where the value of interest is a rate, the confidence interval shows the range of error for that rate. In general, confidence intervals that are close to the rate value reflect the precision of the rate, while those that are very wide reflect imprecision. Where there are wide confidence intervals, associated rates should be interpreted cautiously, the upper and lower limits being considered the top and bottom ranges of possible precise values.

Standard errors. Like confidence intervals, standard errors show the range of error in an average score that is presented.

Between-group comparisons. When comparing outcomes between groups, the overlap in confidence intervals provides an indication of between-group differences. Where there is significant overlap, any apparent difference is more likely to reflect measurement or estimate error.

Odds ratios. When examining a specific health outcome, there can be differences in the rates between two groups (for example, 2015 Regular ADF members and Transitioned ADF members) because of differences in factors other than transition status – such as sex, age, Service or rank – across the comparison groups, particularly if these other factors are associated with the health outcome of interest. If this is the case these factors are potentially confounders, and one method of reducing confounding is to employ a logistic regression model that controls (adjusts) for these factors. The statistical output from a logistic regression model is an odds ratio, or OR. An OR denotes the odds of a particular group (for example, Transitioned ADF) having a specific health outcome compared with a reference group (for example, 2015 Regular ADF).

An OR greater than 1 indicates increased odds of having a particular health outcome compared with the reference group; an OR of less than 1 suggests less likelihood of having a particular health outcome. For example, an OR of 1.7 for Transitioned ADF (compared with 2015 Regular ADF) suggests that members of the Transitioned ADF group have 70% increased odds of having that particular health outcome; conversely, an OR of 0.7 suggests that Transitioned ADF members are 30% less likely than 2015 Regular ADF members to have a particular health outcome. When an OR is greater than 2, we can say that Transitioned ADF members are twice as likely as 2015 Regular ADF to have a particular health outcome. Similarly, if the OR is greater than 3, they would be three times more likely to have a particular health outcome. In the case of the predictive modelling in this report, the key outcome variable has two levels (low symptoms vs elevated symptoms). In all models the reference category is low symptoms, with the odds of having elevated symptoms compared with having low symptoms. Where the predictor has three levels (that is, Service – Navy, Army, Air Force) a reference category is selected for each analysis, and the odds of prediction of the outcome are for the specified group in comparison with that reference; for example, if Air Force is the reference category and the specified group is Army, the OR will reflect the odds of having elevated symptoms for Army compared with Air Force.

Significance. Where a between-group difference is discussed as significant this means that the difference between groups was statistically tested, adjusting for sex, age and Service, and the associated confidence intervals had no overlap between groups. For continuous outcomes that were assessed at all three time points, repeated measures analyses of variance, or ANOVAs, were conducted to examine whether mean scores changed significantly over time. Where Mauchly's Test of Sphericity showed that the assumption of sphericity was violated, the Greenhouse–Geisser adjusted p value is presented. Statistical significance was assessed at the $p < .05$ level. For the purpose of analyses, where outcomes were examined longitudinally data were limited to those individuals with outcomes of interest at all three time points.

Glossary. Refer to the glossary for definitions of key terms used.

2 Methodology

2.1 Study design

2.1.1 Background: MEAO Prospective Study methodology (Time 1 and Time 2)

ADF members who deployed to the Middle East Area of Operations after June 2010 and returned from that index deployment by June 2012 were eligible to participate in the MEAO Prospective Study. In addition, a subsample of primarily combat personnel belonging to certain preselected units were invited to provide additional objective health measures – namely, physical tests (including blood tests) and/or neurocognitive assessments (see Figure 2.1)

Figure 2.1   MEAO Prospective Study assessment phases

SELF-REPORT SURVEY	PHYSICAL TESTING	NEUROCOGNITIVE TESTING
In order to be eligible to participate in the MEAO Prospective Study questionnaire component, individuals must have been members of the ADF and deploying to the MEAO after June 2010 and returning to Australia from deployment by June 2012. The MEAO Prospective Study was provided access to the following deploying units, all of which deployed at different times between June 2010 and June 2012 and for different lengths of time: HMAS *Stuart*, MTF2, MTF3, 1FCU, 1FSU, 2FSU, SOTG, 1CSU, 2CSU, C130s. Orion P3s. Individual	To be invited to participate in the physical testing, individuals must have been eligible to participate in the questionnaire component and be assigned to one of the following combat units: Navy ship, either of the two Special Forces Commando Units (1CDR and 2CDR), either of the two Special Forces Special Air Services (SAS) Units (1SAS and 2SAS), either of the two Army Mentoring Task Force Units (MTF2 and MTF3) and either of the two Army Force Communications Units (1FCU).	To be eligible to participate in the neurocognitive assessments, individuals must have been eligible to participate in the questionnaire component and be assigned to one of the following combat units: either of the two Special Forces Commando Units (1CDR and 2CDR), either of the two Special Forces Special Air Services (SAS) Units (1SAS and 2SAS), either of the two Army Mentoring Task Force Units (MTF2 and MTF3) or either of the two Army Force Communications Units (1FCU).

All data for the MEAO Prospective Study were collected at two time points for each participant. In the first instance participants provided data not more than four months before their index deployment (Time 1: pre-deployment) and then again on average 4.2 months after they returned home (Time 2: post-deployment) (see Figure 2.2). Importantly, individual units deployed at varying times between June 2010 and June 2012 and for varied lengths of time, so the time frame of data collection within the study period (2010 to 2012) varied for each participant. A major strength of this methodology is the ability to document change in individuals over time, including their responses to varied levels of combat exposure and experiences. Furthermore, with individuals acting as their own control, this somewhat mitigated the need for a control comparison group. This approach was also necessary due to the extremely high operational deployment tempo at the time of the study, with most ADF members

eligible for deployment deploying within the study period, limiting the ability to identify an appropriate non-deployed control group.

The Impact of Combat Study was rolled out in concert with the Mental Health and Wellbeing Transition Study and served as an interim time point in the longitudinal surveillance of the MEAO Prospective Study cohort. All participants who completed a pre-deployment survey (Time 1) and/or a post-deployment survey (Time 2) as part of the MEAO Prospective Study were invited to complete a survey as part of the current investigation (Time 3). Participants who were previously identified as having engaged in high-risk roles and therefore likely to experience deployment-related trauma or blast injury and who underwent neurocognitive and/or biological testing as part of the MEAO Prospective Study were invited to do so again, in addition to the self-report survey. A further subgroup of personnel identified as having self-reported blast injury at Time 1, 2 or 3 were targeted to undergo MRI testing in addition to the study components just listed. Finally, all three nested subgroups were also invited to participate in a structured diagnostic interview.

Further details of the self-report survey measures are provided in Section 2.4.1

Figure 2.2   **Data collection timeline for MEAO Prospective Study and Impact of Combat Study**
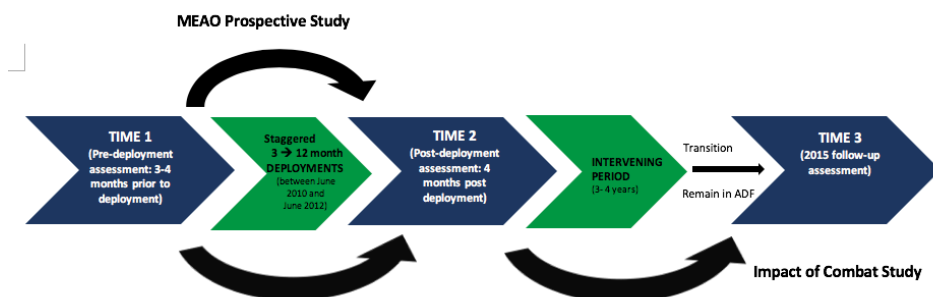
2.2   Samples

This report uses one of the Transition and Wellbeing Research Programme's six overlapping samples. A detailed description of all six samples used in the broader Programme is provided in Annex A.

2.2.1 Sample 5: the MEAO Deployed Cohort[2]

The study sample consisted of 1350 Regular and Transitioned ADF members who deployed to the Middle East Area of Operations after June 2010, returned before June 2012, completed a pre-deployment and/or post-deployment health survey as part of the MEAO Prospective Study in 2010 to 2012, and were included on the Transition and Wellbeing Research Programme Study Roll.[3] Specifically, this cohort consisted of ADF members who participated in the MEAO Prospective Study as a Regular ADF member but who had since transitioned (Transitioned ADF), as well as ADF members who participated in the MEAO Prospective Study as a Regular ADF member and remained in the ADF as a Regular member in 2015 (2015 Regular ADF).

All 1350 eligible participants were invited to complete a self-report survey. In order to determine which of the other study components individuals were eligible for (CIDI, blood testing, neurocognitive testing, MRI assessment), participants were grouped according to the assessments they completed as part of the MEAO Prospective Study (Time 1 and Time 2) and invited to complete additional assessments dependent on these groupings; that is, if participants completed a study element at Time 1 or 2, or both, they were invited to do so again at Time 3. Eligible study participants located outside Australia were invited simply to complete a survey. No additional exclusion criteria were applied to this sample.

2.2.2 Impact of Combat Study nested subgroups

There were three nested subgroups for the study (see Figure 2.3):

- *The Combat Zone Subgroup.* This subgroup consisted of individuals from the broader study sample who participated in the physical testing component of the MEAO Prospective Study in addition to the self-report survey. These individuals were invited to participate in a CIDI (Phase 2) and a blood test (Phase 3) in addition to the Impact of Combat Study self-report survey (Phase 1).

- *The Combat Role High-risk Subgroup.* This subgroup consisted of individuals from within the broader study sample who participated in the physical and neurocognitive testing components of the MEAO Prospective Study in addition to completing the self-report survey. These individuals were invited to participate in

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[2] Note that in the design phase the Impact of Combat Study sample was named the 'Combat Zone Cohort'. This is reflected in some content of other reports in the Programme. The sample was renamed the 'MEAO Deployed Cohort' for the current report to more accurately reflect the cohort members.

[3] A number of individuals who completed the MEAO Prospective Study were not included on the Study Roll. There were various reasons for this – those who were deceased, those who had requested that their details be removed from the MilHOP or TWRP Study Rolls, those who did not provide consent for future contact at the time of their MilHOP participation, and those who opted out of the Transition and Wellbeing Research Programme.

a CIDI (Phase 2), a blood test (Phase 3) and a neurocognitive assessment battery (Phase 4) in addition to the Impact of Combat Study self-report survey (Phase 1).

- *The mTBI Subgroup.* A targeted subgroup of individuals from the Combat Role High-risk Subgroup were also invited to participate in a magnetic resonance imaging assessment (Phase 5) in addition to the self-report survey (Phase 1), CIDI (Phase 2), blood test (Phase 3) and neurocognitive test battery (Phase 4). These individuals were selected because they had previously completed a neurocognitive assessment as part of the MEAO Prospective Study and were identified as having high combat and blast exposure.

Figure 2.3   Impact of Combat Study nested subgroups
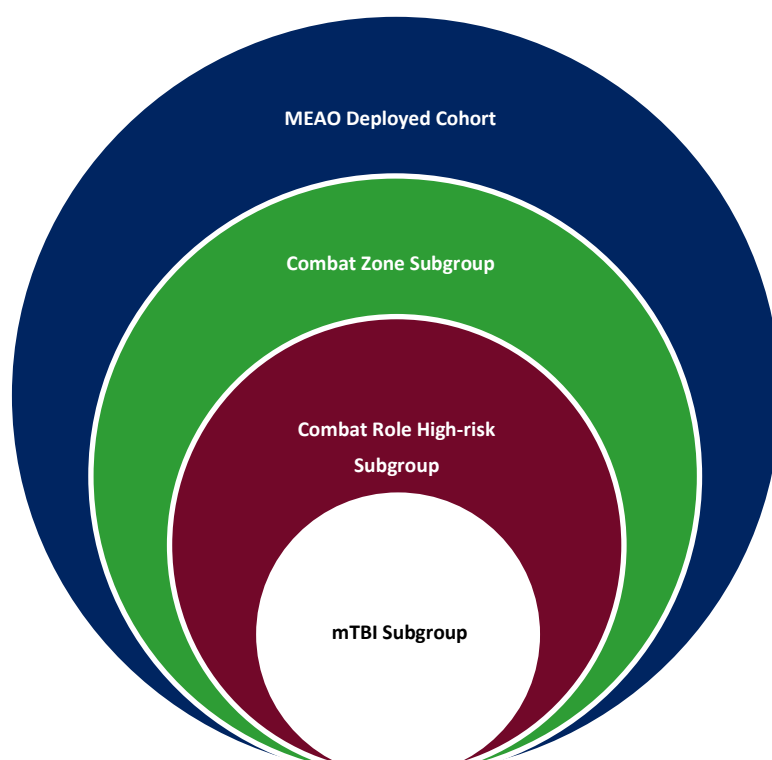
2.3   Statistical analysis

This report uses unweighted data. In order to answer the questions of interest, a number of analytical methods were employed. Analyses were performed in SAS version 9.4. For categorical outcomes, n, % and the 95% confidence interval are reported; for continuous outcomes, the mean and standard error are presented. For

each outcome measure, the effect size is estimated with 95% confidence intervals. For continuous outcomes that were assessed at all three time points, repeated measures ANOVAs were conducted to examine whether mean scores changed significantly over time. Where Mauchly's Test of Sphericity showed that the assumption of sphericity was violated, the Greenhouse–Geisser adjusted p value is presented. Statistical significance was assessed at the $p < .05$ level unless otherwise specified.

For the purpose of this report, responders were defined in a number of ways. Study responders were defined as those individuals who completed any of the study components (survey, CIDI, biological testing, neurocognitive testing, MRI). Responders were further determined for each type of study outcome. Survey responders were defined as those who had completed at least the demographics section of the survey. There were differential response rates for different sections of the survey, so the sample size available for analysis varies according to the outcome being considered and according to the subsample.

For the purpose of analyses, where outcomes are examined longitudinally data were limited to those individuals with outcomes of interest at all three time points. All results are presented for the entire cohort (or subsample) and, for some analyses, also according to whether members of the cohort have transitioned or were still in the Regular ADF in 2015. Where possible, changes over time and between-group differences were statistically tested, although, because of small sample sizes for some outcomes, statistical tests could not be performed and only descriptive data are presented.

2.4   Study elements

2.4.1   Self-report survey

The Impact of Combat Study was rolled out in concert with the Mental Health and Wellbeing Transition Study and served as an interim time point in the longitudinal surveillance of the MEAO Prospective Study cohort. Data presented in the present report were collected at three time points for the MEAO Prospective Study, Time 1 (pre-deployment) and Time 2 (post-deployment) and, for the Impact of Combat Study, Time 3 (2015 follow-up).

In Phase 1 of the Impact of Combat Study, participants belonging to the MEAO Deployed Cohort were invited to complete a 60-minute self-report survey examining mental health problems, psychological distress, physical health problems, wellbeing factors, pathways to care and occupational exposures; the survey was developed at the beginning of the study period in close consultation with DVA and Defence. This survey was the same as that completed by participants in the wider Transition and Wellbeing Research Programme but with a small number of additional questions, as

detailed in Annex A. Where possible, measures were the same as those collected at Times 1 and 2 in the MEAO Prospective Study. Where items were collected at a particular time point this is specified. The scales/items of relevance to the present report are described in the following paragraphs.

Depressive symptoms

Self-reported depression was examined using the Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al., 2001), the nine items of which are scored from zero to three and summed to give a total score between zero and 27. The PHQ-9 gives various levels of diagnostic severity, higher scores indicating higher levels of depression symptoms.

Psychological distress

The Kessler Psychological Distress Scale (K10) (Kessler et al., 2002) is a short 10-item screening questionnaire that yields a global measure of psychological distress based on symptoms of anxiety and depression experienced in the most recent four-week period. Items are scored from one to five and are summed to give a total score between 10 and 50, with higher scores indicating greater levels of psychological distress.

Posttraumatic stress disorder

The Post Traumatic Stress Disorder Checklist – civilian version (PCL-C) (Weathers et al., 1993) is a 17-item self-report measure designed to assess the symptomatic criteria of PTSD according to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV). The 17 questions of the PCL-C are scored from one to five and are summed to give a total symptom severity score between 17 and 85, with higher scores indicating increased severity.

Alcohol use and problem drinking

Alcohol use and problem drinking were examined using the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993), a brief self-report screening instrument developed by the World Health Organization. The instrument consists of 10 questions designed to discern the quantity and frequency of alcohol consumption, possible symptoms of dependence, and reactions or problems related to alcohol. The first eight questions use a five-item continuous scale (scored zero to four), while the last two questions use a three-item scale (scored zero, two or four). A final score is reached by summing across all 10 questions, with higher scores indicative of hazardous and harmful alcohol use, as well as possible alcohol dependence. The AUDIT is widely used in epidemiological and clinical practice for defining at-risk patterns of drinking (Babor et al., 2001).

Anger symptoms

The five-item Dimensions of Anger Reaction Scale (Forbes et al., 2004) assesses anger frequency, intensity and duration and its perceived negative impact on social

relationships, as rated in the preceding four weeks. Responders were instructed to rate the amount of time they had experienced each of the five symptoms of anger in the preceding four weeks on a five-point Likert scale ranging from 1 'none of the time' to 5 'all of the time'. Items are summed to create a total score (from five to 25), with higher scores indicating a higher frequency of anger.

Twelve-month suicidal ideation and behaviour

Twelve-month suicidal ideation and behaviour were assessed via four items that looked specifically at suicidal thoughts, plans and attempts. Three of the items were adapted from the National Survey of Mental Health and Wellbeing (Australian Bureau of Statistics, 2008) and the final item was devised by researchers for use in the present study.

Health symptoms

Items assessing current health symptoms were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015). This 67-item adapted version of a self-report symptom questionnaire, originally based on the Hopkins Symptom Checklist (Derogatis et al., 1974), included respiratory, cardiovascular, musculoskeletal, dermatological, gastrointestinal, genitourinary, neurological and cognitive symptoms. For every symptom experienced in the preceding month, participants were also required to provide an indication of symptom severity on a three-point Likert scale (mild, moderate, severe). For the purpose of the present report, symptoms were dichotomised as present or absent and severity was not assessed. A mean number of health symptoms score was then calculated and used. Individual symptoms were not investigated.

Pain

Items assessing pain intensity and disability were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015). Participants were asked to answer a series of questions on a scale of one to 10 about their current pain, worst pain and average pain in the preceding six-month period. They were also asked to indicate how much their pain had interfered with their daily activities, their recreational and social activities, and their ability to work in the preceding six months. Based on an algorithm by Von Korff et al. (1992), scores on these seven items were categorised into the following grades of pain intensity and disability that were used:

- Grade 0 'pain free'
- Grade I 'low disability – low intensity'
- Grade II 'low disability – high intensity'
- Grade III 'high disability – moderately limiting'
- Grade IV 'high disability – severely limiting'.

Body mass index

BMI was calculated as a function of responders' self-reported weight and height (weight (kg)/height (m)^2). Using guidelines from the Australian Government Department of Health (Department of Health, 2017), BMI scores were categorised as 'underweight' (<18.5), 'normal' (18.5–24.99), 'pre-obese' (25–29.99), 'obese class 1' (30–34.99), 'obese class 2' (35–39.99) and 'obese class 3' (>40).

Length of service

At Time 1 (MEAO Prospective Study) participants were asked, 'To the nearest year, how long have/had you served with the Australian Defence Force as a Regular?'. They entered the number of years they had served.

Number of deployments

At Time 1 (MEAO Prospective Study) participants were asked to report details of all major operations they had been deployed on. The list of operations included warlike, non-warlike, UN peacekeeping and peacemaking operations and humanitarian aid and assistance operations. Participants were asked what country they deployed to, the operation name, the year the deployment started, the number of times deployed in that year and the total time deployed (in months). Number of deployments was calculated from these variables.

Deployment experience

At Time 1 (MEAO Prospective Study) participants were asked, 'Have you ever been on an ADF operational deployment (warlike, peacekeeping, peace-monitoring or humanitarian support)?' They responded yes or no.

Lifetime exposure to traumatic events

Lifetime exposure to trauma was examined at Time 1 (MEAO Prospective Study) and Time 3 (Impact of Combat Study) using questions adapted from the Composite International Diagnostic Interview (CIDI) (World Health Organization, 1997) and modified by McFarlane et al. (2011). Participants were asked to indicate whether or not they had experienced the following traumatic events:

- direct combat

- life-threatening accident

- fire, flood, natural disaster

- witnessed someone badly killed or injured

- rape

- sexual molestation

- serious physical attack or assault

- threatened/harassed without weapon

- threatened with weapon/ held captive/ kidnapped

- tortured or victim of terrorists

- domestic violence

- witnessed domestic violence

- find dead body

- witness suicide/attempted suicide

- child abuse – physical

- child abuse – emotional

- any other stressful event.

If they endorsed a traumatic experience, participants were asked the number of times they were exposed to the event and the age of first and last exposure. Experiences considered are taken from both potential traumatic exposures encountered in the ADF (for example, direct combat) and events that might have occurred outside the ADF in adulthood (for example, serious assault, terrorism) or in childhood (for example, child physical abuse).

Traumatic deployment exposures

Time 3 (Impact of Combat Study) participants were presented with a list of traumatic deployment exposures and asked to indicate how many times they had experienced each one on deployment during their military career and since 2011. Response categories ranged from 'never' to '10+ times'. Examples of events were exposure to serious fear of encountering an IED, discharge of weapon in direct combat, and handling or seeing dead bodies. Items in this section were drawn from the MEAO Census Study (Dobson et al., 2012).

Environmental deployment exposures

Time 3 (Impact of Combat Study) participants were presented with a list of environmental deployment exposures and asked to indicate how many times they had experienced each one on deployment during their military career and since 2011. Response categories ranged from 'never' to '10+ times'. Examples of events were exposure to smoke and/or dust, fumes or fuels, chemicals, hazardous materials, local food or water and noise. Items in this section were drawn from the MEAO Census Study (Dobson et al., 2012).

Traumatic brain injury

Traumatic brain injury was assessed using the Ohio State University Traumatic Brain Injury Identification Method (OSU TBI-ID) (Corrigan & Bogner, 2007), which researchers adapted for use in the current Programme. The OSU TBI-ID is a standardised measure designed to elicit an individual's lifetime history of traumatic brain injury. Questions focused on the types of head or neck injuries incurred, the frequency of these injuries, whether the injuries occurred during military service or deployment, the number of times since 2011, symptoms experienced (for example, loss of consciousness, being dazed and confused, loss of memory), age the first and last time the symptoms occurred, frequency of symptoms, longest time knocked out or unconscious, loss of consciousness related to a drug overdose or being choked, and the occurrence of multiple blows to the head in relation to a history of abuse, contact sports or ADF training/ deployment.

Post-concussive symptoms

Post-concussive symptoms were assessed using a modified version of the Post-concussion Syndrome Checklist (Gouvier et al., 1992), which was used as part of the 2012 MEAO Health Study (Davy et al., 2012). This modified version of the scale required participants to indicate the degree to which they had experienced a list of 11 symptoms in the preceding four weeks as a result of an injury to their head or neck.

Functioning

Functional impairment was assessed using the Sheehan Disability Scale (Sheehan, 1983), a five-item self-report measure of disability due to mental health symptoms in three interrelated domains – work/school, social life and family life. The three items assessing impairment in the three domains are scored from zero to 10 and can yield a total global functional impairment score of between zero and 30.

(See Annex A for a comprehensive list and description of all measures included in the Impact of Combat self-report survey.)

2.4.2   The Composite International Diagnostic Interview

Twelve-month and lifetime ICD-10 rates of the following mental disorders were assessed using the CIDI 3.0: depressive episode, dysthymia, bipolar affective disorder, panic attack, panic disorder, agoraphobia, social phobia, specific phobia, generalised anxiety disorder, obsessive–compulsive disorder, posttraumatic stress disorder, adult separation disorder, harmful alcohol use and dependence, suicidal ideation and behaviour, and intermittent explosive disorder.

In this report individual ICD-10 disorder prevalence rates are presented with hierarchy rules applied in order to be consistent with Australian national rates. Lifetime exposure

to trauma was also examined as part of the PTSD module of the CIDI (Kessler & Ustun, 2004). All Criterion A events listed in the CIDI were examined.[4]

This range of mental disorders was the same as that presented by the 2007 National Survey on Mental Health and Wellbeing (Slade et al., 2009) and was included in the 2010 Mental Health Prevalence and Wellbeing Study (McFarlane et al., 2011b).

2.4.3   Biological testing

Biological testing for the Impact of Combat Study was rolled out as part of the larger Transition and Wellbeing Research Programme, with the aim of collecting all data elements within four to six weeks for each eligible participant.

After being contacted by the research team, consenting participants were posted the relevant paperwork and directed to the nearest suitable collection centre to have their blood collected. Fifty-two millilitres of blood (two x 4.0 ml EDTA tubes, one x 6 ml Li Hep tube, four x 8.5 ml serum tubes, one x 4 ml K2 EDTA tube) was drawn from each participant in order to assess a range of markers. The following markers are included in this report:

- liver enzyme
    - gamma GT

- metabolic
    - cholesterol
    - LDL cholesterol
    - HDL cholesterol
    - HBA1C
    - random glucose
    - triglycerides

- inflammatory and other markers
    - erythrocyte sedimentation rate
    - white cell count
    - interleukin 1b
    - interleukin 6
    - interleukin 10
    - TNF alpha
    - soluble interleukin-2 receptor alpha
    - C-reactive protein
    - brain-derived neurotrophic factor
    - cortisol.

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[4] Criterion A specifies that the event must involve actual or threatened physical threat to the self or others, as well requiring that the person's response involved intense fear, helplessness or horror.

2.4.4   Neurocognitive assessment

Participants were assessed using the standard suite of LabNeuro and IntegNeuro tests administered by the Brain Dynamics Centre at Westmead Millenium Institute. Tests were conducted according to the Brain Resource International Database Methodology (Version 3: May 2009) (Brain Resource International Database, 2009).

LabNeuro tests assessed electrophysiological responses to resting and active cognitive states. Tasks were designed to activate certain cognitive functions, the resultant data indicating electrical brain activity in response to the various stimuli. In contrast, IntegNeuro tests assessed outward performance on a range of cognitive tasks (for example, correct answers and number of errors). Importantly, participants may have differed in electrophysiological activation whilst not differing in observable performance.

A suite of tasks was administered to participants, although only the following two paradigms are included in this report.

Quantitative electroencephalography

qEEG is a method of measuring electrical brain activity via electrode sensors placed on the scalp. Electrodes are positioned across scalp locations corresponding to differential regions of the underlying cerebral cortex (see Figure 2.4). Through high-powered computer analytics these electrical brain signals can be deconstructed into specific spectral frequency bands. The power [μV^2] within each frequency band corresponds to differential physiological brain states and indexes the stability of brain function and its response to stimulation. In general terms, there are four primary spectral frequency bands – beta, alpha, theta and delta (see Figure 2.5). These can be described as follows:

- *Beta (14 to 30Hz).* Beta waves are high frequency and have been associated with cortical excitability. They tend to be found predominantly in frontal or central regions. Beta power increases with the level of brain activation. Studies have found a positive correlation between beta power and underlying cortical metabolism, supporting the suggestion that this frequency band is associated with increased cortical activity. An overabundance of beta activity has been found to be associated with certain forms of psychopathology, specifically anxiety disorders (Kropotov, 2010).

- *Alpha (8 to 13 Hz).* Alpha rhythms tend to predominate in posterior regions (occipital and parietal areas) in primary and secondary sensory areas of the brain. During quiet wakefulness, the alpha rhythm is generally associated with a resting or idle state of consciousness and decreases with the level of brain activation. Alpha peak frequency also reflects working memory capacity. Abnormal levels and

distributions of alpha rhythms have been found to be associated with various psychopathologies, most prominently depression and anxiety disorders (Davidson, 1994, 1998; Heller & Nitschke, 1998; Nitschke, 1998).

- *Theta (4 to 7.5 Hz).* Theta rhythms are considered slow wave and are commonly observed in deep relaxation or sleep. In wakeful EEG recordings, however, theta power has been found to be associated with attentional and memory processes such as encoding and retrieval. Furthermore, the amount of frontline theta can correlate with anxiety scores (Kropotov, 2010).

- *Delta (1 to 4Hz).* Delta is the slowest waveband with the highest amplitudes in the spectrum; it is commonly observed in deep sleep and is not generally prominent during cognitive activity (Kropotov, 2010). Delta rhythms, generated in the thalamus, appear in the EEG when cortical areas are disconnected from the thalamic nuclei. They are usually present only during sleep, particularly the slow-wave phase. The activity can be generated from either the thalamus or the cortex.

Figure 2.4   **A qEEG electrode cap fitted in preparation for data acquisition (left) and electrode locations on the scalp (right)**
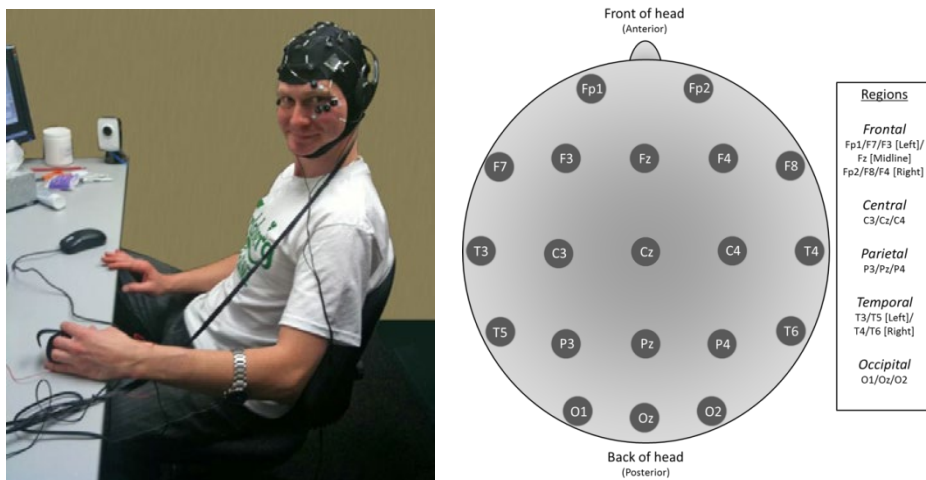
Figure 2.5   The four primary qEEG frequency bands

Beta
Highest frequency (14 to 30 Hz)
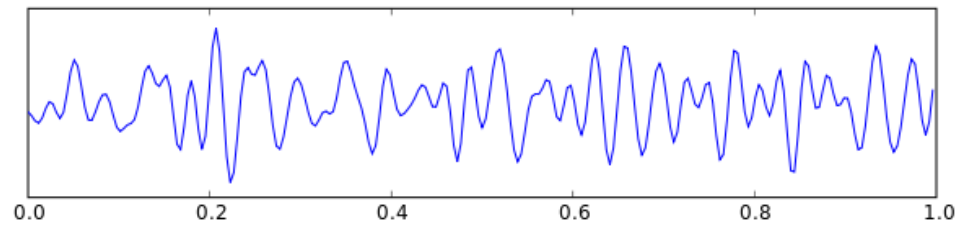
Alpha
Second-highest frequency (8 to 13 Hz)
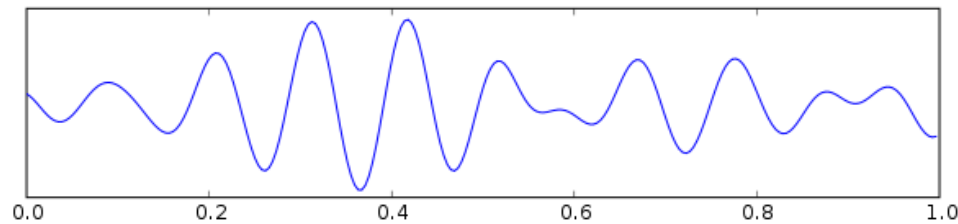
Theta
Second-lowest frequency (4 to 7 Hz)

time (s)
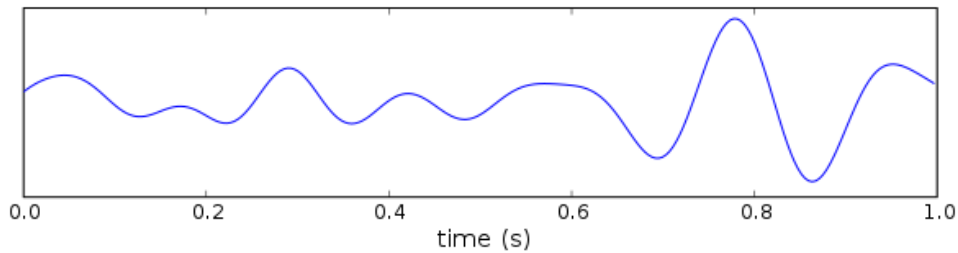
Delta
Lowest frequency (1 to 3 Hz)
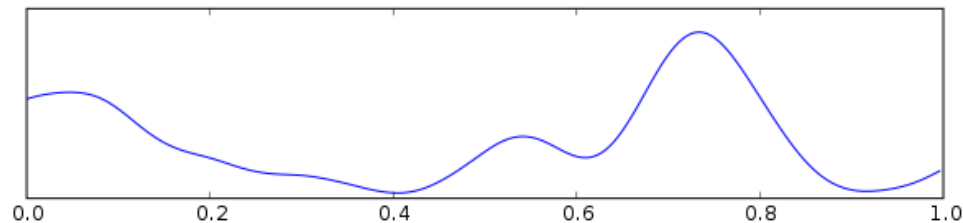
Event-related potential

ERP is an extension of electroencephalography and is a method of measuring brief (sub-second) fluctuations in electrical brain activity that are directly associated with specific sensory and cognitive processing events. Thus, unlike resting-state qEEG, ERP methods are most commonly used to investigate cognition under active task performance conditions (for example, perceptual and executive function tests). The ERP waveform (see Figure 2.6) consists of positive (P) and negative (N) going amplitude deflections (components), which typically peak within defined latency windows. In general terms, early components (<200 ms post-stimulus presentation) reflect preconscious sensory/perceptual processing events, whereas later components (>200 ms) reflect conscious processing events, which are associated with increasingly higher order cognitive functions (that is, effortful information retention, evaluation and manipulation).

The P3wm component

The P3 component is a later latency positive-going amplitude deflection that typically peaks 250 to 500 ms post-stimulus. It has been widely studied because of its close association with higher order executive functions such as working memory. The P3 component is most commonly assessed at midline frontal (Fz), central (Cz) and parietal (Pz) electrodes (Figure 2.6). The P3 amplitude deflection elicited during working memory updating tasks is commonly referred to as the P3wm component. The amplitude of the P3 is an indicator of efficiency of processing, whereby greater amplitude reflects greater efficiency; thus, where working memory efficiency is discussed in this report, this reflects changes or differences in P3 amplitude. Furthermore, it should be noted that, while ERP data are used as a measure of working memory in this study, no corresponding neuropsychological assessments of working memory were included.

The 1-back working memory task

The 1-back task has been widely implemented in the study of working memory function. The task requires participants to visually monitor a series of letters presented one at a time and respond whenever a letter is identical to the one presented immediately before (the target letter) (Figure 2.6). The sequencing of letters varies randomly throughout the task (that is, the target letter occurs irregularly), so performance requires participants to continually update working memory representations on presentation of each new non-target letter (that is, the next presented letter might be a matching target). In this way P3 amplitude deflections elicited by non-target letters are used as an index of cognitive processing events associated with working memory updating (P3wm).

Figure 2.6   The 1-back working memory task (left), an ERP waveform (right) and P3wm electrode locations (bottom)
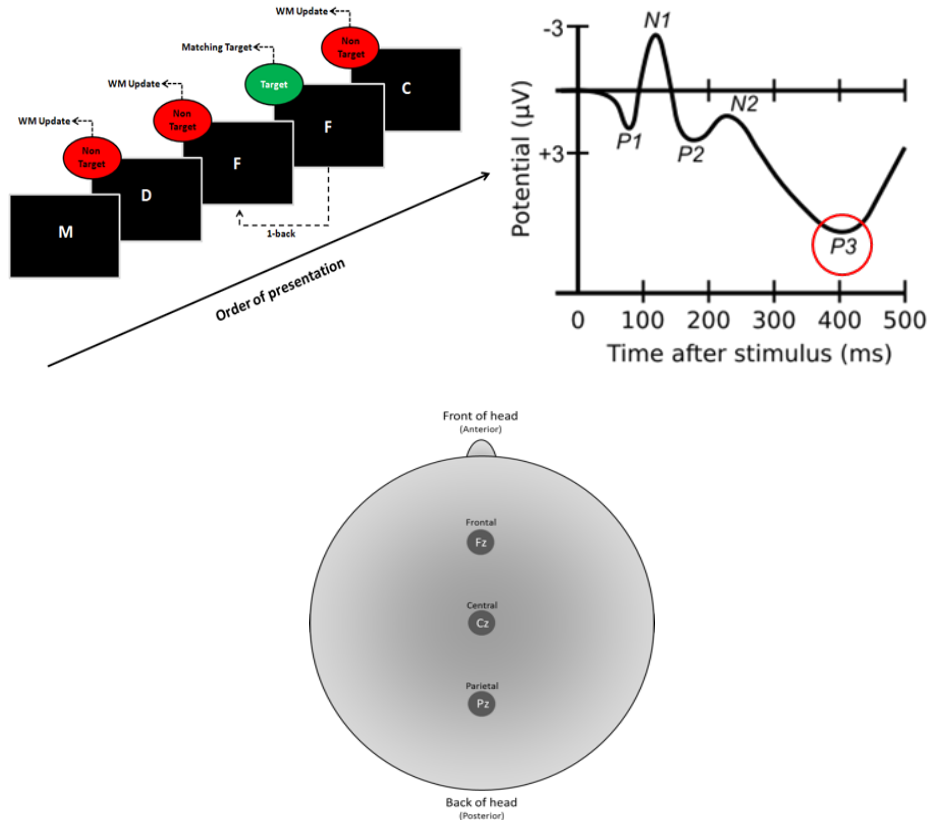
Note: For details of the full LabNeuro and IntegNeuro assessment suite administered to participants, see Annex A.

2.4.5   MRI assessment

A select group of participants (n = 75) who had previously completed a neurocognitive assessment as part of the MEAO Prospective Study and were identified as having high levels of combat and blast exposure (the mTBI Subgroup) were invited to participate in additional structural and functional magnetic resonance imaging.

MRI assessments took approximately an hour to complete and were conducted at the Brain Dynamic Centre, Westmead Millenium Institute, using the standardised Brain Resource International Database protocol (Brain Resource International Database, 2009).

Structural MRI

Structural MRI, or sMRI, measures the volume of grey matter (neurons), white matter (connections) and fluid-filled spaces in the brain. It also measures the local magnetic

fields of water molecules in the brain. Water in different tissue types responds differently to applied magnetic fields, and this enabled the measurement of structure at the millimetre scale.

Structural MRI scans were done using parameters that allowed for two specific forms of analysis: diffusion tensor imaging (DTI) and susceptibility weighted imaging (SWI). These two forms of advanced imaging have been found to be differentially sensitive to different aspects of cortical pathology and complement each other.

- DTI is a form of magnetic resonance imaging that is extremely sensitive to subtle brain pathology, including axonal injury (Mac Donald et al., 2011). It provides an objective, non-invasive measure of structural connectivity in the brain and deficits in white matter that can be indicative of brain injury as well as psychopathology (Mac Donald et al., 2011; Song et al., 2014; White et al., 2008).

- SWI is a similarly sensitive complementary technique for identifying subtle changes to brain pathology. It is particularly sensitive to bleeding in the grey and white matter boundaries, allowing the detection of more subtle injuries (such as micro-haemorrhages) that might not be picked up using conventional imaging techniques.

Functional MRI

Functional MRI, or fMRI, monitors changes in blood flow in the brain that indicate which areas are active during different tasks. It relies on the contrast between the natural magnetic properties of oxygenated versus deoxygenated flow to provide a measure of blood oxygen level–dependent (BOLD) signal change in regions of the brain. Task-related changes in brain activity are measured at a time scale of about two to three seconds and a spatial scale of one millimetre.

Functional MRI tasks

Data on functional MRI were acquired during cognitive tasks that paralleled some of the paradigms from the EEG testing, thereby providing visualisation of processing to complement other measures.

The following tasks were administered during the fMRI testing (Brain Resource International Database, 2009).

- *GoNoGo.* Subjects were repeatedly presented with the word 'press' (for 500 milliseconds) on the screen. They were instructed to press a response button, with the index finger of each hand if the word appeared in the colour green but to not respond if the word appeared in red. Speed and accuracy of responses were equally stressed in the task instructions. This task tested the executive functions of

the pre-frontal and orbito-frontal cortex – in particular, the ability to inhibit or suppress well-learned and inappropriate automatic responses.

- *Oddball.* Subjects were presented with a series of high and low tones at 75 decibels that lasted for 50 milliseconds (with rise and fall times of 5 ms). They were instructed to ignore the low ('background') tones (presented at 500 Hz) and to press, with the index finger of each hand, a response button only when they heard high infrequent ('target') tones, which were presented at 1000 Hz. Speed and accuracy of responses were equally stressed in the task instructions. The task allowed for assessment of processing novel task-relevant information while ignoring task-irrelevant information.

- *Emotion: conscious.* Subjects were told they would see a different series of faces, presented one at a time. They were instructed to pay attention to the faces because they would be asked about them later on. This task assessed brain and body perception of faces showing emotion (the face stimuli were from the 'Gur' set of emotions).

- *Emotion: non-conscious.* Subjects were told they would see a series of different faces presented in pairs but that the first face of each pair would be presented so briefly as to be barely visible. They were told to pay attention because they would be asked about the faces later on.

- *Working memory.* This task consisted of a series of letters presented to the subject on the computer screen. If the same letter appeared twice in a row (that is, a 'target letter'), the subject was required to simultaneously press response buttons with the index finger of each hand. Speed and accuracy of responses were equally stressed in the task instructions. In addition, intermittent chequerboard stimuli elicited 'novelty P300a' visual ERPs. The task is designed to assess sustained attention and working memory. (For the full methodology, including a comprehensive description of all the measures used in the survey, see Annex A.)

3 Response rates and demographics

Response rates and basic cohort characteristics

- A total of 1350 members of the cohort who participated in the MEAO Prospective Health Study (Times 1 and 2) were invited to participate in the Impact of Combat Study (Time 3). Of these, 486 were Transitioned ADF members and 864 were still in the Regular ADF in 2015. For the survey, there was a response rate of 26.5% for the Transitioned ADF and 49.9% for the 2015 Regular ADF. When examined within each nested subgroup, the response rates were similar.

- Impact of Combat Study responders were slightly older than non-responders and, among the responders, those who had remained in the Regular ADF were slightly older than those who had transitioned (M = 38.1 vs M = 35.6).

- The distribution of Service was similar for responders compared with non-responders, although transitioned responders were more likely than Regular serving responders to be from the Army (87.1% vs 63.6%), while Regular serving responders were more likely to be from the Air Force (29.0% vs 10.0%).

- The distribution of sex was similar for responders compared with non-responders. Among the responders, slightly more females remained in the Regular ADF (9.2% vs 5.0%).

- The distribution of ranks among responders compared with non-responders was similar for those who remained in the Regular ADF. The majority of responders were Non-Commissioned Officers (63.4%); they were followed by Officers (26.7%) then Other Ranks (9.9%).

- For those who had transitioned, the distribution of ranks was different for responders compared with non-responders. Responders were more likely to be Non-Commissioned Officers (51.4%) or Officers (11.4%) and less likely to be from Other Ranks (37.1%).

- The distribution of medical fitness for responders compared with non-responders was similar. The majority of Transitioned ADF (83.6%) and 2015 Regular ADF (86.6%) responders were classified as fit.

Demographic characteristics

- The majority of cohort members were in a relationship and living together (68.0%).

- The majority of cohort members had completed educational qualifications at certificate level or above (58.8%); about one-third had completed primary or secondary school only.

- Among those who had transitioned, 71.3% were in full- or part-time work, just under 10% were on a sickness allowance or disability support pension, 7.0% were students, and 3.5% were retired.

- Ninety per cent of the cohort reported being in stable housing at the time of the survey, this figure being slightly lower among those who had transitioned (87.0%).

- A total of 27.1% of cohort members were DVA clients, 45.2% of those being transitioned.

- The majority of the cohort had served in the Regular ADF for eight or more years and 20.7% had served for less than eight years. The distribution of years of service in the Regular ADF was markedly different among those cohort members who had transitioned, with nearly half of those having served less than eight years.

Transitioned cohort members

- The Transitioned ADF group comprised 44.3% Inactive Reservists, 30.4% who were Ex-Serving, and 24.3% Active Reservists.

- The largest group had transitioned three years previously (34.8%); a further 20.0% had transitioned two years previously, and nearly a quarter had transitioned one year or less previously.

- The majority had discharged at their own request (68.7%); 8.7% reported a medical discharge.

- The most commonly reported reasons for transition were better civilian employment prospects (9.6%) and the impact of service life on family (9.6%).

- About two-thirds were in employment (65.2%), the majority working between 21 and 60 hours a week. The most common industries to be employed in were construction (17.3%) and government administration and Defence (17.3%).

- Just over one in three reported a period of unemployment for at least three months since transition (34.8%).

- In relation to DVA support, one in three (34.8%) reported treatment support of some kind (White or Gold Card).

- Almost half reported no ex-service organisation engagement, with 17.4% reporting a single ESO engagement. Similarly, 53.0% had no voluntary organisation involvement, with approximately 15% having engagement with at least one voluntary group.

- A very small number reported having been arrested (4.3%); no one reported imprisonment.

The Impact of Combat Study followed up a deployed cohort of ADF members (the MEAO Deployed Cohort) who were participants in the MEAO Prospective Study, in which the cohort members were assessed before deployment (Time 1) and on their return from deployment (Time 2). The Impact of Combat Study constitutes the third

follow-up of the cohort. Table 3.1 summarises the demographic characteristics of the initial MEAO Prospective Study (Times 1 and 2) and the final Impact of Combat Study (Time 3) populations. Because members of the cohort might or might not have transitioned from the ADF by the third instance of data collection, population demographics are also presented for the MEAO Deployed Cohort according to whether cohort members had transitioned (Transitioned ADF) or remained in the Regular ADF (2015 Regular ADF).

This chapter discusses the basic demographic characteristics of the MEAO Deployed Cohort at Times 1 and 2 (MEAO Prospective Study) and Time 3 (Impact of Combat Study) and the response rates for the Impact of Combat Study overall and each of the individual study components (self-report survey, CIDI, blood collection, neurocognitive assessment, MRI). The basic characteristics of responders and non-responders are also compared, and a more detailed exploration of the demographic profile of the MEAO Deployed Cohort and each nested subsample is presented.

3.1 Demographic characteristics of the MEAO Deployed Cohort invited populations at Times 1 and 2 (MEAO Prospective Study) and Time 3 (Impact of Combat Study)

The mean age of the MEAO Deployed Cohort at Times 1 and 2 was 28.9 years, increasing to 35.0 years at Time 3. Members of the cohort who had transitioned by Time 3 were slightly younger than those who remained in the Regular ADF (M = 32.5 vs M = 36.3). As would be expected, the distribution of age across categories changed between Times 1 and 2 and Time 3, consistent with the natural ageing of the cohort.

At Times 1 and 2 the cohort consisted primarily of Army members (74.5%), followed by Air Force (18.0%); the smallest proportion were from the Navy (7.6%). The distribution of services among the cohort was similar at Time 3 (Army, 74.0%; Air Force, 20.7%; Navy, 5.3%), although there were some differences between those who had transitioned and those who remained in the Regular ADF: a greater proportion of the cohort who had transitioned were Army members (88.7% vs 65.7%) and a smaller proportion were Air Force members (7.8% vs 28.0%).

The majority of the cohort were males, and this distribution did not change between Times 1 and 2 (91.9%) and Time 3 (92.7%). Again, there was a small difference in the distribution of sex for those who had transitioned compared with those who remained in the Regular ADF, there being a slightly smaller proportion of females in the Transitioned ADF group (4.5% vs 8.8%).

At Times 1 and 2 the majority of the cohort were Other Ranks (45.4%) or Non-Commissioned Officers (39.4%); Officers made up the smallest proportion, at 15.2%.

The distribution of ranks in the cohort had changed at Time 3, consistent with career progression among the cohort. At Time 3 Non-Commissioned Officers comprised the largest proportion (47.6%); they were followed by Other Ranks (29.4%) and Officers (17.6%). There was a substantial difference in the distribution of ranks for those who had transitioned compared with those who remained in the Regular ADF: a much larger proportion of those who had transitioned were from Other Ranks (56.2% vs 14.4%), and a smaller proportion were Non-Commissioned Officers (35.2% vs 54.5%) or Officers (6.6% vs 23.7%).

Table 3.1 **Demographics of the MEAO Deployed Cohort invited populations at Times 1 and 2 (Prospective Study) and Time 3 (Impact of Combat Study)**

| | Times 1 and 2: Prospective Study pre- and post-deployment n = 3074 | | Time 3: Impact of Combat follow-up | | | | | |
| | | | Transitioned ADF n = 486 | | 2015 Regular ADF n = 864 | | Total n = 1350 | |
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Mean age (SE)		28.9 (0.1)		32.5 (0.4)		36.3 (0.3)		35.0 (0.2)
Age group								
18–27	1698	55.2 (53.5–57.0)	161	33.1 (28.9–37.3)	101	11.7 (9.5–13.8)	262	19.4 (17.3–21.5)
28–37	853	27.7 (26.2–29.3)	230	47.3 (42.9–51.8)	428	49.5 (46.2–52.9)	658	48.7 (46.1–51.4)
38–47	418	13.6 (12.4–14.8)	58	11.9 (9.1–14.8)	239	27.7 (24.7–30.6)	297	22.0 (19.8–24.2)
48–57	94	3.1 (2.4–3.7)	22	4.5 (2.7–6.4)	86	10.0 (8.0–11.9)	108	8.0 (6.6–9.4)
58+	9	0.3 (0.1–0.5)	15	3.1 (1.5–4.6)	10	1.2 (0.4–1.9)	25	1.9 (1.1–2.6)
Missing	2	0.1 (0.0–0.2)	0	0.0	0	0.0	0	0.0
Service								
Navy	233	7.6 (6.6–8.5)	17	3.5 (1.9–5.1)	54	6.3 (4.6–7.9)	71	5.3 (4.1–6.5)
Army	2289	74.5 (72.9–76.0)	431	88.7 (85.9–91.5)	568	65.7 (62.6–68.9)	999	74.0 (71.7–76.3)
Air Force	552	18.0 (16.6–19.3)	38	7.8 (5.4–10.2)	242	28.0 (25.0–31.0)	280	20.7 (18.6–22.9)
Sex								
Male	2824	91.9 (90.9–92.8)	464	95.5 (93.6–97.3)	788	91.2 (89.3–93.1)	1252	92.7 (91.4–94.1)
Female	250	8.1 (7.2–9.1)	22	4.5 (2.7–6.4)	76	8.8 (6.9–10.7)	98	7.3 (5.9–8.6)
Rank								
OFFR	467	15.2 (13.9–16.5)	32	6.6 (4.4–8.8)	205	23.7 (20.9–26.6)	237	17.6 (15.5–19.6)
NCO	1212	39.4 (37.7–41.2)	171	35.2 (30.9–39.4)	471	54.5 (51.2–57.8)	642	47.6 (44.9–50.2)
Other	1395	45.4 (43.6–47.1)	273	56.2 (51.8–60.6)	124	14.4 (12.0–16.7)	397	29.4 (27.0–31.8)
Missing	–	–	10	2.1 (0.8–3.3)	64	7.4 (5.7–9.2)	74	5.5 (4.3–6.7)

3.2 Response rates for each component in the cross-sectional MEAO Deployed Cohort and subgroups for Transitioned ADF and the 2015 Regular ADF

Figures 3.1, 3.2 and 3.3 show cohort attrition over study time points for the survey, biological testing results and neurocognitive assessment components of the Impact of Combat Study.

As Figure 3.1 shows, 1871 participants completed the survey at Time 1, 1324 of whom went on to complete the Time 2 survey. Nineteen participants who completed a survey at Time 2 did not complete one at Time 1. Of the 1324 participants who completed both a Time 1 and a Time 2 survey, 472 also completed a survey at Time 3, giving them a data point for the survey at every time point. Eighty-eight participants completed a survey at both Time 1 and Time 3 (but not Time 2), nine completed a survey at Time 2 and Time 3 (but not Time 1) and five only completed a Time 3 survey.[5]

Figure 3.1   Survey responders for the MEAO Deployed Cohort
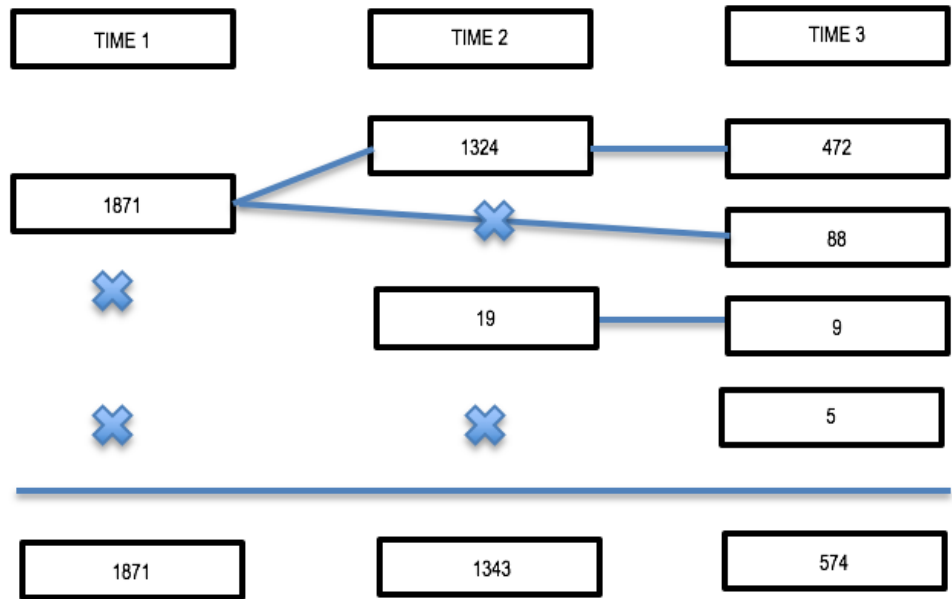
As Figure 3.2 shows, 599 participants completed biological testing at Time 1, and 348 of them went on to complete at Time 2. Nine participants who completed blood testing at Time 2 did not complete at Time 1. Of the 348 participants who completed

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[5] A small number of individuals who were on the Study Roll for the MEAO Prospective Study but who were non-responders at Time 1 and Time 2 were included in the Impact of Combat Study. These individuals have only Time 3 data.

both Time 1 and Time 2 blood testing, 64 also completed at Time 3, providing data points for all three time points. Thirty-eight participants completed blood testing at both Time 1 and Time 3 (but not Time 2) and nine participants only completed at Time 3.[6]

Figure 3.2   Biological testing responders for the MEAO Deployed Cohort
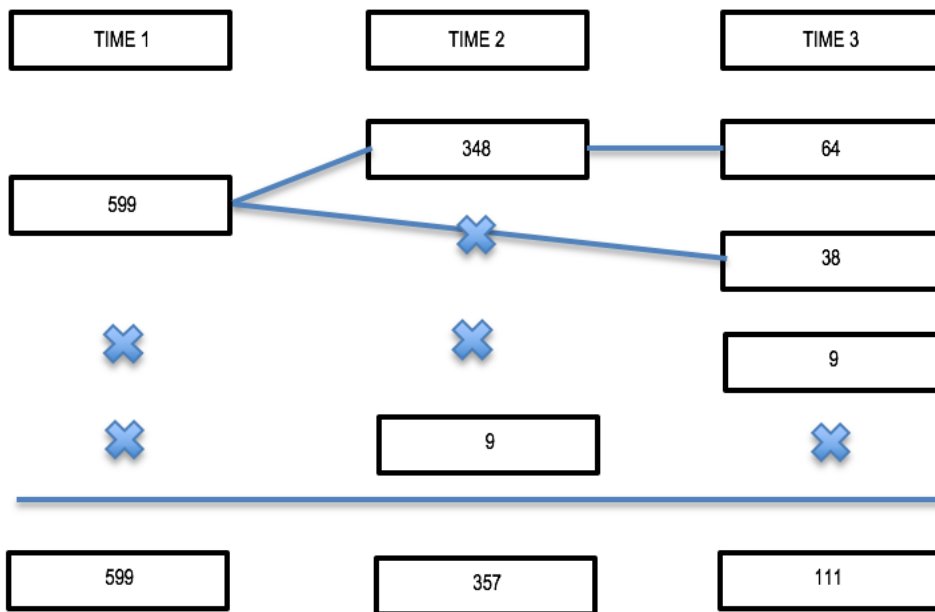
As Figure 3.3 shows, 274 participants completed neurocognitive testing at Time 1; 167 of them went on to complete the neurocognitive testing at Time 2, and 51 completed at all three time points. Thirty-three participants completed neurocognitive testing at both Time 1 and Time 3 (but not Time 2) and two participants only completed at Time 3.[7]

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[6] A small number of individuals who were eligible for biological testing in the MEAO Prospective Study but were non-respondents at Time 1 and Time 2 completed biological testing in the Impact of Combat Study. These individuals have only Time 3 biological test data.

[7] A small number of individuals who were eligible for neurocognitive testing in the MEAO Prospective Study but were non-respondents at Time 1 and Time 2 completed neurocognitive testing in the Impact of Combat Study. These individuals have only Time 3 neurocognitive test data.

Figure 3.3   Neurocognitive testing responders for the MEAO Deployed Cohort
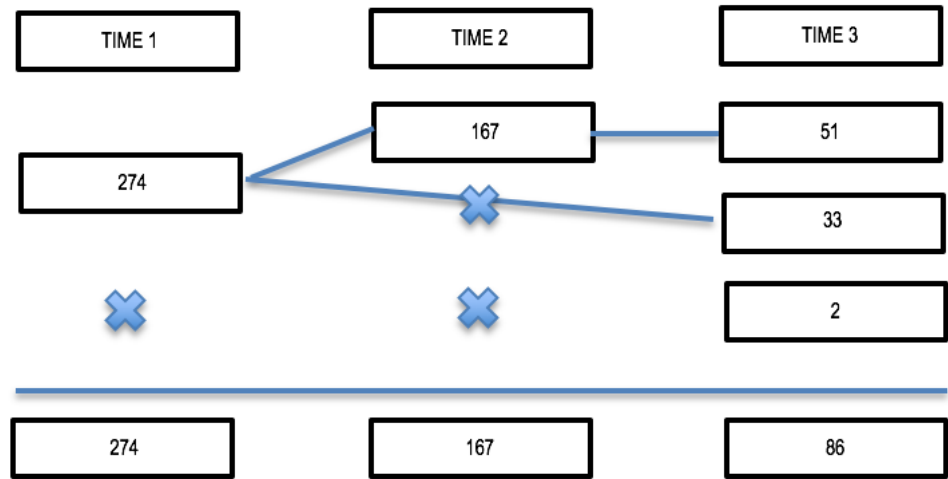
Table 3.2 shows response rates for the Impact of Combat Study, for the MEAO Deployed Cohort and for each nested subgroup (Combat Zone Subgroup, Combat Role High-risk Subgroup, mTBI Subgroup). A total of 1350 members of the cohort who participated in the MEAO Prospective Study (Times 1 and 2) were invited to participate in the Impact of Combat Study (Time 3). Of these, 486 were transitioned and 864 remained in the Regular ADF. For the survey component of this Impact of Combat Study, there was a response rate of 26.5% for the Transitioned ADF members of the cohort and a much higher 49.9% of the 2015 Regular ADF members. When examined within each nested subgroup, the pattern was similar.

Response rates for the CIDI were calculated as a proportion of the sample who were Impact of Combat Study responders (since being a responder determined eligibility for a CIDI invitation). Response rates for all other study components were calculated as a proportion of the subsample invited to complete that specific study component. In general, response rates for the CIDI and other outcome measures were successively higher among each nested subgroup as a result of their being nested, as well as the increasingly intensive directed follow-up within each subsample.

For the CIDI component of the study, response rates were higher overall, primarily because of the more intensive contact protocol implemented. Among the cohort as a whole, just under half of the Transitioned ADF members who participated in the study completed a CIDI. This was higher than among the 2015 Regular ADF members, where about one-fifth of those who participated completed a CIDI.

A total of 6.6% of Transitioned and 27.0% of Regular serving cohort members who were eligible to complete biological testing (Combat Zone Subgroup, Combat Role High-risk Subgroup, mTBI Subgroup) were responders. This pattern was similar for the nested subgroups. A total of 22.0% of Transitioned and 40.0% of Regular serving cohort members who were eligible to complete neurocognitive testing (Combat Role High-risk Subgroup and mTBI Subgroup) were responders. Finally, 42.9% of eligible Transitioned and 50.0% of eligible Regular serving cohort members (mTBI Subgroup) were responders for the MRI component of the study.

Table 3.2 Cross-sectional response rates for study components in the MEAO Deployed Cohort and nested subgroups, according to whether members had transitioned from or remained in the Regular ADF in 2015

	MEAO Deployed Cohort n = 1350				Combat Zone Subgroup n = 563				Combat Role High-risk Subgroup n = 247				mTBI Subgroup n = 75			
	Transitioned ADF n = 486		2015 Regular ADF n = 864		Transitioned ADF n = 244		2015 Regular ADF n = 319		Transitioned ADF n = 82		2015 Regular ADF n = 165		Transitioned ADF n = 21		2015 Regular ADF n = 54	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Survey	129	26.5 (22.6–30.5)	431	49.9 (46.6–53.2)	49	20.1 (15.1–25.1)	135	42.3 (36.9–47.7)	15	18.3 (9.9–26.7)	66	40.0 (32.5–47.5)	7	33.3 (13.2–53.5)	28	51.9 (38.5–65.2)
CIDI[a]	71	48.6 (40.5–56.7)	95	20.9 (17.1–24.6)	37	56.1 (44.1–68.0)	83	52.2 (44.4–60.0)	17	60.7 (42.6–78.8)	45	54.9 (44.1–65.6)	5	50.0 (19.0–81.0)	14	46.7 (28.8–64.5)
Biological testing	–	–	–	–	16	6.6 (3.5–9.7)	86	27.0 (22.1–31.8)	7	8.5 (2.5–14.6)	44	26.7 (19.9–33.4)	2	9.5 (0.0–22.1)	18	33.3 (20.8–45.9)
Neurocognitive testing	–	–	–	–	–	–	–	–	18	22.0 (13.0–30.9)	66	40.0 (32.5–47.5)	7	33.3 (13.2–53.5)	25	46.3 (33.0–59.6)
MRI	–	–	–	–	–	–	–	–	–	–	–	–	9	42.9 (21.7–64.0)	27	50.0 (36.7–63.3)

a. As a proportion of responders to any component. One person completed wave 3 CIDI that did not respond to anything at Time 1 and was excluded from other analyses (in CTSB).
Notes: Unweighted data. Response rates presented are calculated as the proportion of those invited to participate in the study.

3.3 Unweighted demographic characteristics of non-responders and responders in the MEAO Deployed Cohort among those who had transitioned and those who remained in the Regular ADF in 2015

Table 3.3 shows the demographic characteristics of the MEAO Deployed Cohort responders and non-responders according to whether they had transitioned or remained in the Regular ADF in 2015.

Table 3.3 **Unweighted demographic characteristics of non-responders and responders in the MEAO Deployed Cohort in Transitioned ADF and 2015 Regular ADF**

	Non-responders				Responders			
	Transitioned ADF n = 346		2015 Regular ADF n = 430		Transitioned ADF n = 140		2015 Regular ADF n = 434	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Mean age (SE)		31.3 (0.4)		34.5 (0.4)		35.6 (0.9)		38.1 (0.4)
Age group								
18–27	125	36.1 (31.1–41.2)	68	15.8 (12.4–19.3)	36	25.7 (18.5–33.0)	33	7.6 (5.1–10.1)
28–37	169	48.8 (43.6–54.1)	237	55.1 (50.4–59.8)	61	43.6 (35.4–51.8)	191	44.0 (39.3–48.7)
38–47	38	11.0 (7.7–14.3)	94	21.9 (18.0–25.8)	20	14.3 (8.5–20.1)	145	33.4 (29.0–37.8)
48–57	9	2.6 (0.9–4.3)	29	6.7 (4.4–9.1)	13	9.3 (4.5–14.1)	57	13.1 (10.0–16.3)
58+	5	1.4 (0.2–2.7)	2	0.5 (0.0–1.1)	10	7.1 (2.9–11.4)	8	1.8 (0.6–3.1)
Service								
Navy	13	3.8 (1.8–5.8)	22	5.1 (3.0–7.2)	4	2.9 (0.1–5.6)	32	7.4 (4.9–9.8)
Army	309	89.3 (86.1–92.6)	292	67.9 (63.5–72.3)	122	87.1 (81.6–92.7)	276	63.6 (59.1–68.1)
Air Force	24	6.9 (4.3–9.6)	116	27.0 (22.8–31.2)	14	10.0 (5.0–15.0)	126	29.0 (24.8–33.3)
Sex								
Male	331	95.7 (93.5–97.8)	394	91.6 (89.0–94.2)	133	95.0 (91.4–98.6)	394	90.8 (88.1–93.5)
Female	15	4.3 (2.2–6.5)	36	8.4 (5.8–11.0)	7	5.0 (1.4–8.6)	40	9.2 (6.5–11.9)
Rank								
OFFR	16	4.6 (2.4–6.8)	89	20.7 (16.9–24.5)	16	11.4 (6.2–16.7)	116	26.7 (22.6–30.9)
NCO	99	28.6 (23.9–33.4)	196	45.6 (40.9–50.3)	72	51.4 (43.1–59.7)	275	63.4 (58.8–67.9)
Other	221	63.9 (58.8–68.9)	81	18.8 (15.1–22.5)	52	37.1 (29.1–45.1)	43	9.9 (7.1–12.7)
Missing	10	2.9 (1.1–4.7)	64	14.9 (11.5–18.2)	0	0.0	0	0.0
Medical fitness[a]								
Fit	278	80.3 (76.2–84.5)	318	74.0 (69.8–78.1)	117	83.6 (77.4–89.7)	376	86.6 (83.4–89.8)
Unfit	58	16.8 (12.8–20.7)	48	11.2 (8.2–14.1)	22	15.7 (9.7–21.7)	55	12.7 (9.5–15.8)
Missing	10	2.9 (1.1–4.7)	64	14.9 (11.5–18.2)	1	0.7 (0.0–2.1)	3	0.7 (0.0–1.5)

a. For details of the reclassification of Medical Employment Classification (MEC) to medical fitness, see the Glossary.
Notes: Unweighted data. Response rates presented are calculated as the proportion of those invited to participate in the study.

Impact of Combat Study responders were slightly older than non-responders and, among responders, those who remained in the Regular ADF were slightly older than those who had transitioned (M = 38.1 vs M = 35.6). The distribution of Services was similar for responders compared with non-responders, there being again a difference between those who remained in the Regular ADF compared with those who had

transitioned. Transitioned responders were more likely to be from the Army compared with Regular serving responders (87.1% vs 63.6%), while Regular serving responders were more likely to be from the Air Force (29.0% vs 10.0%). The distribution of sex was similar for responders compared with non-responders. Among responders, slightly more females remained in the Regular ADF (9.2% vs 5.0%). The distribution of ranks among responders compared with non-responders was similar for those who remained in the Regular ADF, the majority of responders being Non-Commissioned Officers (63.4%), followed by Officers (26.7%) then Other Ranks (9.9%). For those who had transitioned, the distribution of ranks was different for responders compared with non-responders. Responders were more likely to be Non-Commissioned Officers (51.4% vs 28.6%) or Officers (11.4% vs 4.6%) and less likely to be from Other Ranks (37.1% vs 63.9%). Finally, the distribution of medical fitness for responders compared with non-responders was similar: the majority of Transitioned ADF (83.6%) and 2015 Regular ADF (86.6%) responders were classified as fit.

3.4 Other characteristics of the MEAO Deployed Cohort

Table 3.4 shows further unweighted demographic characteristics of the MEAO Deployed Cohort responders as at Time 3. The majority of cohort members were in a relationship and living together (68.0%); a further 11.7% were in a relationship but living apart, and just 13.7% were not in a relationship.

The majority of the cohort had completed educational qualifications of certificate level or above (58.8%); about one-third had completed primary or secondary school only.

Only 71.3% of those who had transitioned were in full- or part-time work; just under 10% were on a sickness allowance or disability support pension, 7.0% were students, and 3.5% were retired. The main source of income among the Transitioned ADF was a wage or salary (69.6%); about 10% reported being on some form of pension or compensation. Ninety per cent of the cohort reported being in stable housing at the time of the survey; this figure was slightly lower among those who had transitioned (87.0%).

Table 3.4   **Demographic characteristics in the MEAO Deployed Cohort for Transitioned ADF and 2015 Regular ADF**

Demographic characteristics	Transitioned ADF n = 115		2015 Regular ADF n = 397		Total n = 512	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Relationship status						
In a relationship and living together	78	67.8 (59.3–76.4)	270	68.0 (63.4–72.6)	348	68.0 (63.9–72.0)
In a relationship not living together	9	7.8 (2.9–12.7)	51	12.8 (9.6–16.1)	60	11.7 (8.9–14.5)
Not in a relationship	19	16.5 (9.7–23.3)	51	12.8 (9.6–16.1)	70	13.7 (10.7–16.6)
Education						
Primary/secondary school	37	32.2 (23.6–40.7)	140	35.3 (30.6–40.0)	177	34.6 (30.5–38.7)
Certificate	23	20.0 (12.7–27.3)	84	21.2 (17.1–25.2)	107	20.9 (17.4–24.4)
Diploma	31	27.0 (18.8–35.1)	62	15.6 (12.0–19.2)	93	18.2 (14.8–21.5)
University	16	13.9 (7.6–20.2)	85	21.4 (17.4–25.4)	101	19.7 (16.3–23.2)
Employment status						
Full-/ part-time paid work	82	71.3 (63.0–79.6)	397	100.0 (100.0–100.0)	479	93.6 (91.4–95.7)
Unpaid work	1	0.9 (0.0–2.6)	–		1	0.2 (0.0–0.6)
Unemployed/looking for work	1	0.9 (0.0–2.6)	–	–	1	0.2 (0.0–0.6)
Unemployed – sickness allowance/disability support pension	11	9.6 (4.2–14.9)	–	–	11	2.1 (0.9–3.4)
Student	8	7.0 (2.3–11.6)	–	–	8	1.6 (0.5–2.6)
Retired	4	3.5 (0.1–6.8)	–	–	4	0.8 (0.0–1.5)
Main source of income						
Wage/salary/own business/partnership	80	69.6 (61.2–78.0)	397	100.0 (100.0–100.0)	477	93.2 (91.0–95.4)
Age pension	6	5.2 (1.2–9.3)	–	–	6	1.2 (0.2–2.1)
Invalidity service pension	4	3.5 (0.1–6.8)	–	–	4	0.8 (0.0–1.5)
VEA/SRCA/MRCA compensation	2	1.7 (0.0–4.1)	–	–	2	0.4 (0.0–0.9)
Dividends/interest/investments	0	0 (0.0–0.0)	–	–	0	0 (0.0–0.0)
Other pension/benefit/allowance	6	5.2 (1.2–9.3)	–	–	6	1.2 (0.2–2.1)
Superannuation	4	3.5 (0.1–6.8)	–	–	4	0.8 (0.0–1.5)
Other	4	3.5 (0.1–6.8)	–	–	4	0.8 (0.0–1.5)
Stable housing						
No	6	5.2 (1.2–9.3)	7	1.8 (0.5–3.1)	13	2.5 (1.2–3.9)
Yes	100	87.0 (80.8–93.1)	361	90.9 (88.1–93.8)	461	90.0 (87.4–92.6)

Note: Missing – 2015 Regular ADF: relationship status 25 (6.3%), education 26 (6.5%), stable housing 29 (7.3%);
Transitioned ADF: relationship status 9 (7.8%), education 8 (7.0%), employment 8 (7.0%), main income 9 (7.8%), stable housing 9 (7.8%).

Table 3.5 shows the service characteristics of the cohort. Overall, 27.1% of the cohort were DVA clients, although among those cohort members who had transitioned this proportion was much higher, with 45.2% DVA clients. The majority of the cohort had served in the Regular ADF for eight or more years; 20.7% had served for less than eight years. The distribution of years of service in the Regular ADF was markedly different among cohort members who had transitioned, approximately half having served less than eight years.

Table 3.5   Service characteristics in the MEAO Deployed Cohort for Transitioned ADF and 2015 Regular ADF

Service characteristics	Transitioned ADF n = 115		2015 Regular ADF n = 397		Total n = 512	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
DVA status						
DVA client	52	45.2 (36.1–54.3)	87	21.9 (17.8–26.0)	139	27.1 (23.3–31.0)
Not DVA client	56	48.7 (39.6–57.8)	255	64.2 (59.5–68.9)	311	60.7 (56.5–65.0)
Time in Regular ADF[a]						
1 months – 3.9 years	2	1.7 (0.0–4.1)	0	0.0 (0.0–0.0)	2	0.4 (0.0–0.9)
4–7.9 years	56	48.7 (39.6–57.8)	48	12.1 (8.9–15.3)	104	20.3 (16.8–23.8)
8–11.9 years	15	13.0 (6.9–19.2)	99	24.9 (20.7–29.2)	114	22.3 (18.7–25.9)
12–15.9 years	8	7.0 (2.3–11.6)	78	19.6 (15.7–23.6)	86	16.8 (13.6–20.0)
16–19.9 years	2	1.7 (0.0–4.1)	43	10.8 (7.8–13.9)	45	8.8 (6.3–11.2)
20+ years	22	19.1 (11.9–26.3)	104	26.2 (21.9–30.5)	126	24.6 (20.9–28.3)

a. Either 2015 Regular ADF or on discharge from Regular ADF service.
Note: Missing – 2015 Regular ADF: DVA status: 55 (13.9%), time in Regular ADF 25 (6.3%); Transitioned: DVA status 7 (6.1%), time in Regular ADF 10 (8.7%).

Table 3.6 shows the transition characteristics of those members of the cohort who had transitioned by 2015. Among them, 44.3% were Inactive Reservists, 30.4% were Ex-Serving and 24.3% were Active Reservists. When asked the number of years since transition, three years previously was the most commonly reported category (34.8%); a further 20.0% had transitioned two years previously, and nearly one-quarter had transitioned a year or less before. The majority of these cohort members had discharged at their own request (68.7%); 8.7% reported a medical discharge.

The most commonly reported reasons for transition were better civilian employment prospects (9.6%) and the impact of service life on family (9.6%). Further, 7.8% cited posting issues (such as not being happy with the location) as their main reason for leaving, followed by mental health problems (7.0%), work not exciting or challenging enough (5.2%), inability to plan life outside of work (4.3%), harassment/bullying/discrimination (3.5%) and physical health problems (3.5%).

Table 3.6   Transition characteristics in the MEAO Deployed Cohort for Transitioned ADF

Transition characteristics	Transitioned ADF n = 115	
	n	% (95% CI)
Serving status		
Ex-serving	35	30.4 (22.0–38.8)
Reservist		
Active Reservist	28	24.3 (16.5–32.2)
Inactive Reservist	51	44.3 (35.3–53.4)
Years since transition		
0	14	12.2 (6.2–18.2)
1	18	15.7 (9.0–22.3)
2	23	20.0 (12.7–27.3)
3	40	34.8 (26.1–43.5)
4	7	6.1 (1.7–10.5)
5+	0	0.0 (0.0–0.0)
Type of discharge/resignation		
Compulsory age	5	4.3 (0.6–8.1)
Own request	79	68.7 (60.2–77.2)
Unsuitable for further training	1	0.9 (0.0–2.6)
End of fixed period	3	2.6 (0.0–5.5)
End of initial enlistment period/return of service obligation	5	4.3 (0.6–8.1)
Limited tenured appointment (officers)	0	0.0 (0.0–0.0)
Not offered re-engagement	0	0.0 (0.0–0.0)
Accepted voluntary redundancy	0	0.0 (0.0–0.0)
Compassionate grounds	0	0.0 (0.0–0.0)
Non-voluntary discharge – administrative	0	0.0 (0.0–0.0)
Medical discharge	10	8.7 (3.5–13.8)
Other	2	1.7 (0.0–4.1)
Main reason for transition		
Better employment prospects in civilian life	11	9.6 (4.2–14.9)
Lack of promotion prospects	1	0.9 (0.0–2.6)
Inability to plan life outside of work	5	4.3 (0.6–8.1)
Impact of service life on family	11	9.6 (4.2–14.9)
Pressure from family	1	0.9 (0.0–2.6)
Didn't want to be away from home	2	1.7 (0.0–4.1)
Pregnancy	0	0.0 (0.0–0.0)
Posting issues (e.g. unhappy with location or nature of postings)	9	7.8 (2.9–12.7)
Too many deployments	0	0.0 (0.0–0.0)
Not enough deployments	0	0.0 (0.0–0.0)
Experiences on deployment	2	1.7 (0.0–4.1)
Work not exciting or challenging enough	6	5.2 (1.2–9.3)
Dissatisfaction with pay	0	0.0 (0.0–0.0)
Personal experience of harassment/ bullying/ discrimination in the ADF	4	3.5 (0.1–6.8)
Personal experience of violence in the ADF	1	0.9 (0.0–2.6)
Disciplinary action or criminal offence	0	0.0 (0.0–0.0)
Service terminated	0	0.0 (0.0–0.0)
Physical health problems	4	3.5 (0.1–6.8)
Mental health problems	8	7.0 (2.3–11.6)
Other	5	4.3 (0.6–8.1)

Note: Missing – serving status 1 (0.9%), years since transition 7 (6.1%), type of discharge/resignation 10 (8.7%), main reason for transition 45 (39.1%).

Table 3.7 provides details of civilian employment among the Transitioned members of the MEAO Deployed Cohort. About two-thirds of these members were in employment (65.2%), the majority of them working between 21 and 60 hours a week. The most common industries for them to be employed in were construction (17.3%) and government administration and Defence (17.3%). A smaller proportion reported being employed in mining (10.7%), health and community services (8.0%) and emergency services (8.0%). Transport and storage (6.7%) and retail (5.3%) were the next most common. Just over one in three Transitioned members of the cohort reported a period of unemployment of at least three months since transition (34.8%). In relation to DVA support, one in three (34.8%) reported treatment support of some form (White or Gold Card), the majority of these being White Cards.

Table 3.8 shows rates of ex-service organisation engagement and incarceration among the Transitioned members of the MEAO Deployed Cohort. Almost half of these members reported no ex-service organisation engagement and 17.4% reported a single ESO engagement. Similarly, 53.0% had no voluntary organisation involvement and approximately 15% reported engagement with at least one voluntary group.

A very small number of these members reported having been arrested (4.3%). No one reported imprisonment.

Table 3.7   Civilian employment and DVA support in the MEAO Deployed Cohort for Transitioned ADF

Civilian employment and DVA support	Transitioned ADF n = 115	
	n	% (95% CI)
Civilian employment		
Employed	75	65.2 (56.5–73.9)
Not employed	30	26.1 (18.1–34.1)
Hours worked in preceding week [a]		
0–20 hours	4	5.3 (0.2–10.4)
21–40 hours	29	38.7 (27.6–49.7)
41–60 hours	36	48.0 (36.7–59.3)
61–80 hours	3	4.0 (0.0–8.4)
80-plus hours	1	1.3 (0.0–3.9)
Civilian employment industry [a]		
Agriculture, forestry and fishing	3	4.0 (0.0–8.4)
Mining	8	10.7 (3.7–17.7)
Manufacturing	0	0.0 (0.0–0.0)
Electricity, gas and water supply	3	4.0 (0.0–8.4)
Construction	13	17.3 (8.8–25.9)
Wholesale trade	1	1.3 (0.0–3.9)
Retail trade	4	5.3 (0.2–10.4)
Accommodation, cafes and restaurants	2	2.7 (0.0–6.3)
Transport and storage	5	6.7 (1.0–12.3)
Communication services	1	1.3 (0.0–3.9)
Finance and insurance	0	0.0 (0.0–0.0)
Property and business services	2	2.7 (0.0–6.3)
Government administration and Defence	13	17.3 (8.8–25.9)
Education	2	2.7 (0.0–6.3)
Health and community services	6	8.0 (1.9–14.1)
Cultural and recreational services	2	2.7 (0.0–6.3)
Personal and other services	3	4.0 (0.0–8.4)
Emergency services	6	8.0 (1.9–14.1)
Unemployment: at least 3-month period since transition		
Yes	40	34.8 (26.1–43.5)
No	66	57.4 (48.4–66.4)
DVA support since transition		
Treatment support (White or Gold Card)	40	34.8 (26.1–43.5)
White Card	37	32.2 (23.6–40.7)
Gold Card	3	2.6 (0.0–5.5)

a: Proportion of Employed Transition ADF only.
Note: Missing – civilian employment 10 (8.7%), hours worked 2 (2.7%), industry 1 (1.3%), unemployment 9 (7.8%).

Table 3.8   ESO engagement and incarcerations in the MEAO Deployed Cohort for Transitioned ADF

Criterion	Transitioned ADF n = 115	
	n	% (95% CI)
No. of ex-service organisations joined		
None	57	49.6 (40.4–58.7)
1	20	17.4 (10.5–24.3)
2	6	5.2 (1.2–9.3)
3	1	0.9 (0.0–2.6)
4	0	0.0 (0.0–0.0)
5-plus	0	0.0 (0.0–0.0)
No. of other voluntary groups joined		
None	61	53.0 (43.9–62.2)
1	9	7.8 (2.9–12.7)
2	8	7.0 (2.3–11.6)
3	1	0.9 (0.0–2.6)
4	1	0.9 (0.0–2.6)
5-plus	0	0.0 (0.0–0.0)
Incarcerations since transition		
Arrested	5	4.3 (0.6–8.1)
Imprisoned	0	0.0 (0.0–0.0)

Note: Missing – Ex-service organisations: 31 (27.0%), other organisations 35 (30.4%).

4   Longitudinal health status of the MEAO Deployed Cohort

Mental health

- For all mental health measures, there were small to moderate increases in symptoms over time and, correspondingly, small to moderate increases in the proportion of the cohort with subsyndromal or probable disorder.

Depressive symptoms

- Average depressive symptoms were low in the cohort at all times but did increase with time, the largest change occurring between Times 2 and 3 (M = 2.5 vs M = 5.1).

- The majority of cohort members fell below both screening and epidemiological cut-offs for probable depressive episodes at Time 1 (91.5%), Time 2 (86.2%) and Time 3 (66.7%), there being a steady increase in the proportion with subsyndromal and probable disorder over time. At Time 3, 27.9% of the cohort were subsyndromal and 5.4% had probable depressive episodes.

Psychological distress

- Average psychological distress symptoms were low in the cohort at all times. They were relatively stable between Time 1 (M = 13.4) and Time 2 (M = 13.8) and increased at Time 3 (M = 16.6).

- The majority of the MEAO Deployed Cohort fell below both screening and epidemiological cut-offs for probable psychological distress at Time 1 (84.1%), Time 2 (79.4%) and Time 3 (69.6%). The proportion of cohort members who were subsyndromal increased from Time 1 (12.1%) to Time 2 (16.6%), then remained stable at Time 3 (16.4%).

- In the case of probable disorder, a different pattern was observed: the proportion of cohort members with probable psychological distress did not change between Time 1 (3.7%) and Time 2 (4.0%) but increased dramatically at Time 3 (14.0%).

Posttraumatic stress symptoms

- There were small increases in mean posttraumatic stress symptoms in the cohort from Time 1 (M = 20.0) to Time 2 (M = 22.3) and again at Time 3 (M = 25.3).

- The majority of cohort members scored below subsyndromal and probable disorder cut-offs at Time 1, Time 2 and Time 3.

- The proportion of the cohort with subsyndromal posttraumatic stress symptoms nearly doubled from Time 1 (7.1%) to Time 2 (13.4%) and increased again, to 21.7%, at Time 3. The

proportion of the cohort with probable PTSD was very low at all three time points but showed the same pattern of increase over time (Time 1, 0.2%; Time 2, 1.7%; Time 3, 3.6%).

Alcohol use and problem drinking

- There was very little change in mean AUDIT scores over time in the cohort, with no change from Time 1 (M = 6.3) to Time 2 (M = 6.3) and only a small increase at Time 3 (M = 6.6).

- Almost three-quarters of the cohort were below subsyndromal and probable alcohol disorder cut-offs at Time 1 (71.2%) and Time 2 (72.1%), falling slightly, to 67.5%, at Time 3. Almost one-third of the cohort scored above the screening cut-off on the AUDIT at Time 1 (28.1%), Time 2 (26.0%) and Time 3 (29.6%).

- Rates of probable alcohol disorder were extremely low in the cohort but showed a pattern of increasing over time (Time 1, 0.7%; Time 2, 1.9%; Time 3, 2.9%).

Anger symptoms

- Mean anger scores increased over time (Time 1, M = 6.7; Time 2, M = 7.3; Time 3, M = 8.5). The proportion of participants with problematic anger also increased steadily from Time 1 through to Time 3 (Time 1, 5.5%; Time 2, 11.6%; Time 3, 19.2%).

Suicidality

- The proportion of cohort members with any suicidality increased slightly from Time 1 (2.2%) to Time 2 (3.6%) and increased dramatically at Time 3 (12.7%).

- No members of the cohort reported formulating a suicide plan or attempting suicide at Time 1 or Time 2; at Time 3, 2.6% of the cohort reported making a plan and 1.0% had made an attempt.

Lifetime and 12-month ICD-10 disorder

- Overall, members of the cohort who had transitioned reported higher lifetime and 12-month rates of each ICD-10 mental disorder class compared with those who remained in the Regular ADF.

- Almost 80% of cohort members who had transitioned in 2015 met criteria for any lifetime ICD-10 mental disorder; this compares with two-thirds (66.7%) of those who remained in the Regular ADF. Alcohol (Transitioned ADF, 59.7%; 2015 Regular ADF, 47.4%) and anxiety disorders (Transitioned ADF, 55.6%; 2015 Regular ADF, 32.5%) were the most prevalent lifetime disorder classes for the cohort, the rates of affective disorders being lower (Transitioned ADF, 37.5%; 2015 Regular ADF, 18.4%).

- Lifetime rates of PTSD in the cohort were 29.2% for members who had transitioned and 13.2% for those who remained in the Regular ADF.

- One in two members of the cohort who had transitioned met criteria for a mental disorder in the preceding 12 months compared with about one in five of those who remained in the Regular ADF.

- Anxiety disorders were the most prevalent 12-month disorders in the cohort: 41.7% of members who had transitioned and 18.4% of those who were still regular serving members met ICD-10 criteria.

- The most common 12-month affective disorder in the cohort was depressive episodes (Transitioned ADF, 9.7%; 2015 Regular ADF, 4.4%); this was followed by bipolar affective disorder (Transitioned ADF, 8.3%; 2015 Regular ADF, 2.6%).

- The most common 12-month anxiety disorder type in members of the cohort who had transitioned was PTSD (22.2%); this was followed by panic attacks (15.3%) and agoraphobia (12.5%). A slightly different pattern was observed among cohort members who remained in the Regular ADF, with panic attacks (10.5%) being the most common 12-month anxiety disorder in this group, followed by PTSD (7.0%).

- Rates of 12-month alcohol disorders were low in the cohort and were more commonly reported among members who had transitioned. The most common 12-month alcohol disorder class was alcohol dependence (Transitioned ADF, 9.7%; 2015 Regular ADF, 3.5%).

Physical health

- The mean number of physical health symptoms reported increased from Time 1 (M = 7.7, SE = 0.4) to Time 2 (M = 10.4, SE = 0.5) and was higher again at Time 3 (M = 12.8, SE = 0.5).

- The majority of participants in both populations reported experiencing Grade I pain intensity and disability (Transitioned ADF, 55.9%; 2015 Regular ADF, 62.6%).

- A higher proportion of those who had transitioned (9.7%) reported the highest grade of pain intensity and disability (Grade IV); this compared with only 5.9% of those who remained in the Regular ADF.

- Over 50% of participants fell within the pre-obese range (53.7%) at Time 1. The proportion increased to almost 60% (58.9%) at Time 2 and was higher still at Time 3 (66.3%).

- Just over a third of participants (34.7%) were in the normal weight range at Time 1. The proportion decreased at Time 2, to 26.3%, and reduced again at Time 3 (24.2%).

Biological measures

- Overall, biological outcomes were well within the normal ranges for a healthy population and only small changes were observed in the outcomes measured. For a number of markers no changes were found, although there were some consistent patterns of change across groups of measures.

- The liver enzyme gamma GT showed an increase from Time 1 to Time 2 then decreased to fall in the middle of that range at Time 3.

- Of the metabolic indices, LDL cholesterol was stable from Time 1 to Time 2 and increased slightly at Time 3. Mean total HDL cholesterol and triglycerides were stable at all three time points.

- Mean HBA1C showed a trend towards decreasing over time, while mean random glucose stayed relatively stable over time.

- Of the inflammatory markers, ESR showed a trend towards increasing over time, while mean white cell count was relatively stable over time.

- Interleukin 1b, interleukin 10 and SIL-2RA all decreased over time.

- A number of markers – Interleukin 6 (IL-6), tumour necrosis factor alpha (TNF alpha), C-reactive protein (CRP), cortisol and brain-derived neurotrophic factor (BDNF)– showed a pattern of increase between Time 1 and Time 2 and a subsequent decrease at Time 3.

4.1   Mental health outcomes

This section provides a detailed summary of the patterns of self-reported psychological distress, alcohol consumption and alcohol-related problems, PTSD, depression, anger and suicidality among MEAO Deployed Cohort members at the three time points:

- MEAO Prospective Study pre-deployment assessment (Time 1)

- MEAO Prospective Study post-deployment assessment (Time 2)

- Impact of Combat Study five-year follow-up (Time 3).

Only participants with data for all three time points are included in the longitudinal analyses.

The key measures used are as follows:

- psychological distress – the Kessler Psychological Distress Scale (K10), a short, easily administered screening instrument for psychological distress

- posttraumatic stress symptoms – the Posttraumatic Stress Disorder Checklist – civilian version, or PCL-C, a 17-item scale for measuring PTSD symptoms

- alcohol use and problem drinking – the Alcohol Use Disorders Identification Test, or AUDIT, a brief self-report instrument that is widely used in epidemiological and clinical practice for defining at-risk patterns of drinking

- depressive symptoms – the Patient Health Questionnaire-9, or PHQ-9, the nine-item depression module of the questionnaire

- anger symptoms – the five-item Dimensions of Anger Reaction Scale, assessing anger frequency, intensity and duration and anger's perceived negative impact on social relationships in the preceding four weeks

- suicidality – a short, four-item measure examining suicidal thoughts, plans and attempts, adapted from the National Survey of Mental Health and Wellbeing (Australian Bureau of Statistics, 2008).

Further details of how these measures are scored are provided in the relevant sections of this chapter.

Two sets of cut-offs on the K10, PCL-C and AUDIT – the optimal epidemiological cut-off and the optimal screening cut-off – were developed as part of the Mental Health Prevalence and Wellbeing Study (McFarlane et al., 2011b) and are used in the present report. The epidemiological cut-offs give the 'closest estimate of the true prevalence of 30-day ICD-10 disorder as measured by the CIDI' (McFarlane et al., 2011b, p. 103). The screening cut-offs reflect a broader spectrum of moderate to severe symptoms rather than diagnosable disorder, allowing for potential early intervention. These screening cut-offs maximise potential identification of true cases but include a larger proportion of 'false positives' than the epidemiological cut-offs. Screening cut-offs are also reported in this section.

In the present report, where scores on the relevant measures are above the optimal screening cut-off but below the optimal epidemiological cut-off, this is referred to as 'subsyndromal'; where scores on the relevant measures are above both the optimal screening and the epidemiological cut-offs, this is referred to as 'probable disorder'. For anger symptoms and suicidality there are no screening or epidemiological cut-offs.

4.1.1 Depressive symptoms (PHQ-9)

This section looks at depressive symptomatology reported by the MEAO Deployed Cohort longitudinally across the three-time points mentioned – the MEAO Prospective Study pre-deployment assessment (Time 1), the MEAO Prospective Study post-deployment assessment (Time 2) and the Impact of Combat Study five-year follow-up (Time 3).

The nine items forming the depression module of the Patient Health Questionnaire were designed to correspond with the nine criteria used to form a diagnosis of DSM-IV depressive disorder (Kroenke et al., 2001). Participants rated the severity of each symptom item over the preceding two weeks on a four-point (that is, zero to 3) Likert scale. Items were then summed to generate a continuous measure of depressive symptoms (with possible scores ranging from zero to 27). The PHQ-9 is widely used and has shown strong psychometric properties, including high diagnostic validity, internal consistency and test–retest reliability (Kroenke et al., 2001; Manea et al., 2012; Wittkampf et al., 2007).

In addition to a mean score, two sets of cut-off values derived from the 2010 Regular ADF Mental Health Prevalence and Wellbeing Study were used – an optimal

epidemiological cut-off of 18 (probable disorder) and an optimal screening cut-off of 6 (subsyndromal disorder). The optimal screening cut-off is the value that maximises the sum of the sensitivity and specificity (the proportion of those with and without an affective disorder who are correctly classified) and can be used to identify individuals who might need care. The epidemiological cut-off is much more stringent and is therefore used as an indicator of probable disorder.

Table 4.1 and Figure 4.1 show mean depressive symptoms on the Patient Health Questionnaire in the MEAO Deployed Cohort over time. There was a significant increase in mean PHQ scores over time ($F_{(2,424)} = 142.65$; $p < .0001$). Mean PHQ scores were low but increased slightly from Time 1 to Time 2 (M = 1.6, SE = 0.1 and M = 2.5, SE = 0.2 respectively) then more than doubled again at Time 3 (M = 5.1, SE = 0.3).

Table 4.1 and Figure 4.2 show depressive symptom status in the MEAO Deployed Cohort over time. When the data were examined according to screening and epidemiological cut-offs, a similar pattern was observed. The vast majority of the MEAO Deployed Cohort fell below both the screening and the epidemiological cut-off points at Time 1 and Time 2 (Time 1, 91.5%; Time 2, 86.2%). At Time 3 the proportion reduced to 66.7% of the entire cohort.

Of the very small proportion of participants who scored above the screening cut-off at Time 1 (8.4%), 7.7% were subsyndromal and a very small 0.7% reported symptoms suggestive of probable disorder. The proportion of participants who were subsyndromal increased to 12.4% at Time 2 and more than doubled at Time 3 (27.9%). The proportion of participants with probable disorder doubled at Time 2 (1.4%) and was greater again at Time 3 (5.4%).

Table 4.1   Depressive symptoms (PHQ-9) in the MEAO Deployed Cohort (n = 426) over time

	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
No disorder (below both screening and epi cut-offs)	390	91.5 (88.9–94.2)	367	86.2 (82.9–89.4)	284	66.7 (62.2–71.1)
Subsyndromal (above screening cut-off but below epi cut-off)	33	7.7 (5.2–10.3)	53	12.4 (9.3–15.6)	119	27.9 (23.7–32.2)
Probable disorder (above both screening and epi cut-offs)	3	0.7 (0.0–1.5)	6	1.4 (0.3–2.5)	23	5.4 (3.3–7.5)
Mean score (M, SE)		1.6 (0.1)		2.5 (0.2)		5.1 (0.3)

Note: Total scores for Prospective Study included only those with scores on all variables. Impact of Combat had mean scores imputed for missings.

Figure 4.1   Mean depressive symptoms in the MEAO Deployed Cohort over time
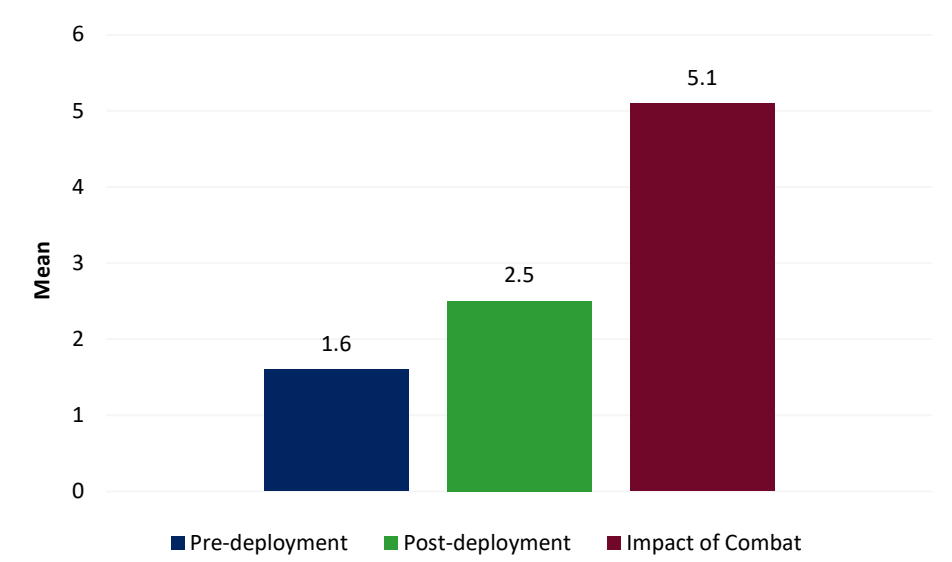
Figure 4.2   Depressive symptom status in the MEAO Deployed Cohort over time
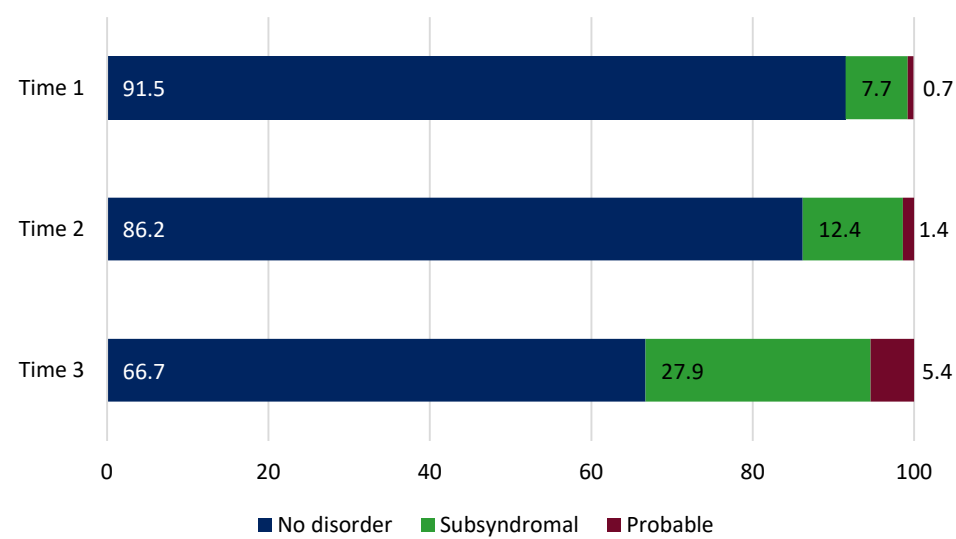
4.1.2 Psychological distress (K10)

This section provides a detailed summary of the pattern of psychological distress reported by the MEAO Deployed Cohort longitudinally across the three-time points – the MEAO Prospective Study pre-deployment assessment (Time 1), the MEAO Prospective Study post-deployment assessment (Time 2) and the Impact of Combat Study five-year follow-up (Time 3).

The K10 is a 10-item screening questionnaire for psychological distress that was developed for use in the US National Health Interview Survey (Kessler et al., 2002). Originally designed as a short, easily administered screen for psychological distress, it is typically used to inform and complement clinical interviews and to quantify levels of distress in those who are in particular need of treatment. It is commonly used in mental health screening in the ADF.

Responders were instructed to rate the amount of time they had experienced one of 10 emotional states during the preceding four weeks (for example, tired for no good reason, nervous, hopeless, depressed). The 10 questions are scored from 1 to 5, the responder must indicate how often they have been feeling that way using one of the following response options: 'all of the time' (5), 'most of the time', 'some of the time', 'a little of the time' or 'none of the time' (1). Scores for the 10 questions are then summed to give a total score from 10 to 50.

In addition to a mean score, two sets of cut-offs derived from the 2010 Regular ADF Mental Health Prevalence and Wellbeing Study were used in this part of the study.

Psychometric analysis of the K10 indicated different optimal screening cut-offs for affective disorder (19) and anxiety disorder (17) (McFarlane et al., 2011b). In order to most effectively capture both disorders, the conservative optimal screening cut-off of 17 was used. This cut-off can be used to identify individuals who might need care (subsyndromal disorder). To ascertain the level of probable disorder in the population, a more stringent epidemiological cut-off of 25 was applied.

Table 4.2 and Figure 4.3 show mean psychological distress on the K10 in the MEAO Deployed Cohort over time. There was a significant increase in mean K10 scores over time ($F_{(2,430)} = 40.93$, p <.0001). Mean K10 scores were similar at Time 1 and Time 2 (M = 13.4, SE = 0.2 and M = 13.8, SE = 0.2 respectively) and were higher at Time 3 (M = 16.6, SE = 0.4).

Table 4.2 and Figure 4.4 show psychological distress status in the MEAO Deployed Cohort over time. When the data were examined according to subsyndromal and probable disorder cut-offs, a similar pattern was apparent. The majority of the MEAO Deployed Cohort were below the K10 screening cut-off at both Time 1 and Time 2

(84.3% and 79.4% respectively). At Time 3 this proportion reduced to 69.7% of the cohort.

Of the small proportion above the screening cut-off at Time 1, 12.0% had subsyndromal symptom levels, while a further 3.7% had symptom levels indicative of probable disorder. The proportion of those who were subsyndromal increased to 16.7% at Time 2, then remained relatively stable at Time 3 (16.4%). The proportion of the MEAO Deployed Cohort with symptom levels indicating probable disorder did not increase at Time 2 (3.9%) but increased dramatically at Time 3, to 13.9%.

Table 4.2   Psychological distress (K10) in the MEAO Deployed Cohort (n = 432) over time

	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
No disorder (below both screening and epi cut-offs)	364	84.3 (80.8–87.7)	343	79.4 (75.6–83.2)	301	69.7 (65.3–74.0)
Subsyndromal (above screening cut-off but below epi cut-off)	52	12.0 (9.0–15.1)	72	16.7 (13.2–20.2)	71	16.4 (12.9–19.9)
Probable disorder (above both screening and epi cut-offs)	16	3.7 (1.9–5.5)	17	3.9 (2.1–5.8)	60	13.9 (10.6–17.2)
Mean score (SE)		13.4 (0.2)		13.8 (0.2)		16.6 (0.4)

Note: Total scores for Prospective Study included only those with scores on all variables. Impact of Combat had mean scores imputed for missings.

Figure 4.3   Mean psychological distress in the MEAO Deployed Cohort over time
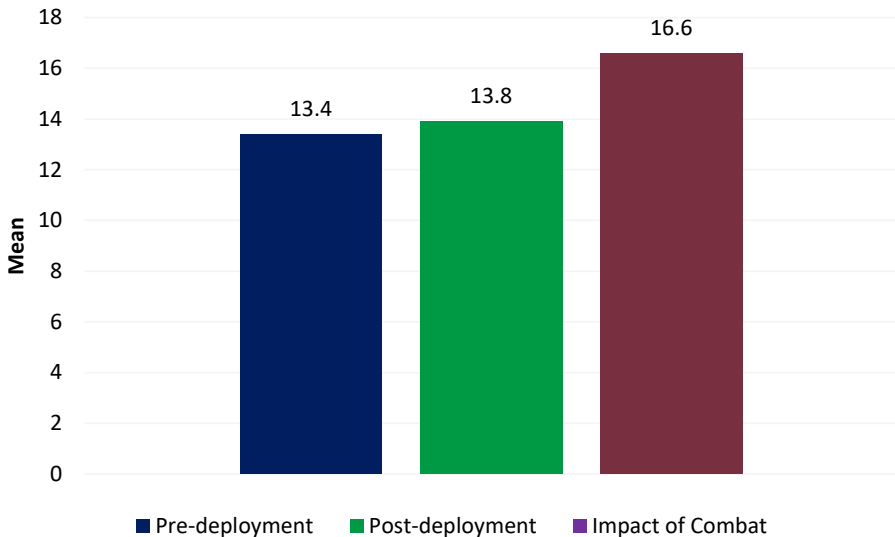
Figure 4.4   **Psychological distress status in the MEAO Deployed Cohort over time**

Time	No disorder	Subsyndromal	Probable
Time 1	84.3	12.0	3.7
Time 2	79.4	16.7	3.9
Time 3	69.7	16.4	13.9

■ No disorder   ■ Subsyndromal   ■ Probable
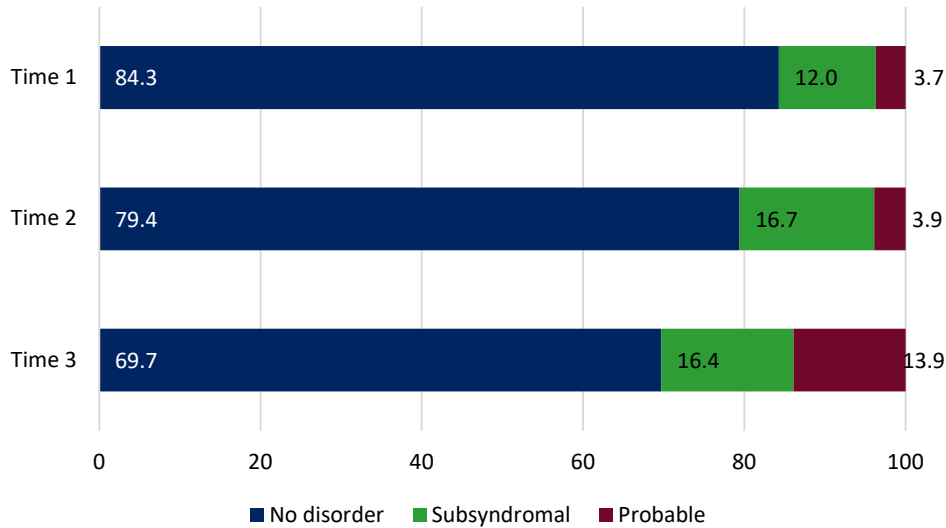
4.1.3   Posttraumatic stress symptoms (PCL-C)

This section provides a detailed summary of the pattern of posttraumatic stress symptoms reported by the MEAO Deployed Cohort longitudinally across the three time points – the MEAO Prospective Study pre-deployment assessment (Time 1), the MEAO Prospective Study post-deployment assessment (Time 2) and the Impact of Combat Study five-year follow-up (Time 3).

Responders were instructed to indicate how much they were bothered by each symptom in the preceding month by using one of the following response options: 'not at all' (1), 'a little bit' (2), 'moderately' (3), 'quite a bit' (4) and 'extremely' (5). The 17–item PCL-C was used instead of the PCL-5 (PCL for DSM-5) in order to allow comparisons to be made with the 2010 Regular ADF cohort. Additional questions relating to DSM-5 PTSD were included in the survey but are not discussed here.

The 17 questions of the PCL-C are scored from 1 to 5 and are summed to give a total score from 17 to 85.

In addition to mean PCL-C scores, an optimal screening cut-off of 29 (subsyndromal disorder) and an optimal epidemiological cut-off of 53 (probable disorder) were used. These cut-offs were derived from the 2010 Regular ADF Mental Health Prevalence and Wellbeing Study.

Table 4.3 and Figure 4.5 show mean posttraumatic stress symptoms on the PCL-C in the MEAO Deployed Cohort over time. There was a significant increase in mean PCL-C

scores over time (F(2,409) = 102.73, p <.0001). Mean PCL-C scores increased slightly from Time 1 (M = 20.0, SE = 0.3) to Time 2 (M = 22.3, SE = 0.4) and then again at Time 3 (M = 25.3, SE = 0.5).

Table 4.3 and Figure 4.6 show posttraumatic stress symptom status in the MEAO Deployed Cohort over time. When the data were examined according to subsyndromal and the more stringent probable disorder cut-off points, a similar pattern emerged. The majority of participants reported PTSD symptomatology that placed them below both the screening and the epidemiological cut-offs at Time 1 (92.7%) and Time 2 (84.9%). At Time 3 the proportion decreased to 74.7%.

Table 4.3   Posttraumatic stress symptoms (PCL-C) in the MEAO Deployed Cohort (n = 411) over time

	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
No disorder (below both screening and epi cut-offs)	381	92.7 (90.2–95.2)	349	84.9 (81.5–88.4)	307	74.7 (70.5–78.9)
Subsyndromal (above screening cut-off but below epi cut-off)	29	7.1 (4.6–9.5)	55	13.4 (10.1–16.7)	89	21.7 (17.7–25.6)
Probable disorder (above both screening and epi cut-offs)	1	0.2 (0.0–0.7)	7	1.7 (0.5–3.0)	15	3.6 (1.8–5.5)
Mean score (M, SE)		20.0 (0.3)		22.3 (0.4)		25.3 (0.5)

Note: Total scores for Prospective Study included only those with scores on all variables. Impact of Combat had mean scores imputed for missings.

Figure 4.5   Mean posttraumatic stress symptoms in the MEAO Deployed Cohort over time
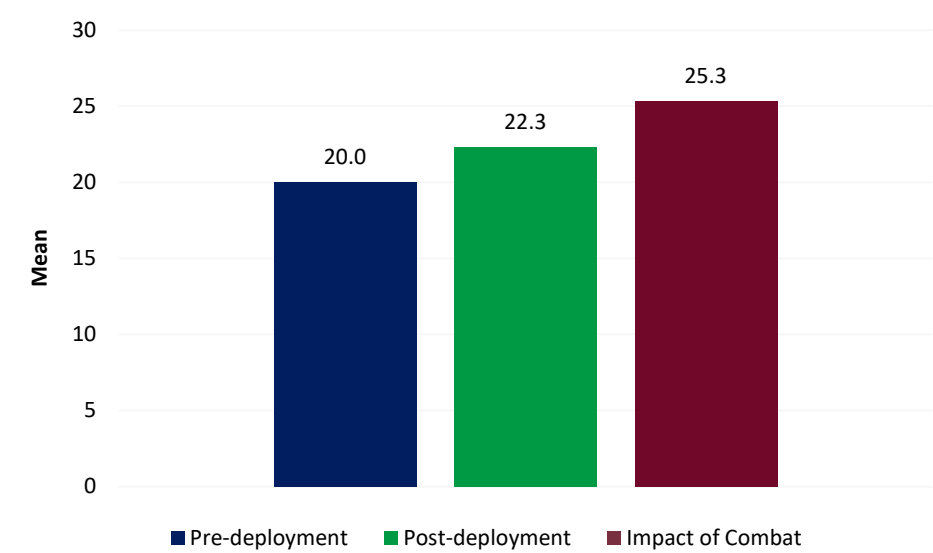
Figure 4.6   Posttraumatic stress symptom status in the MEAO Deployed Cohort over time
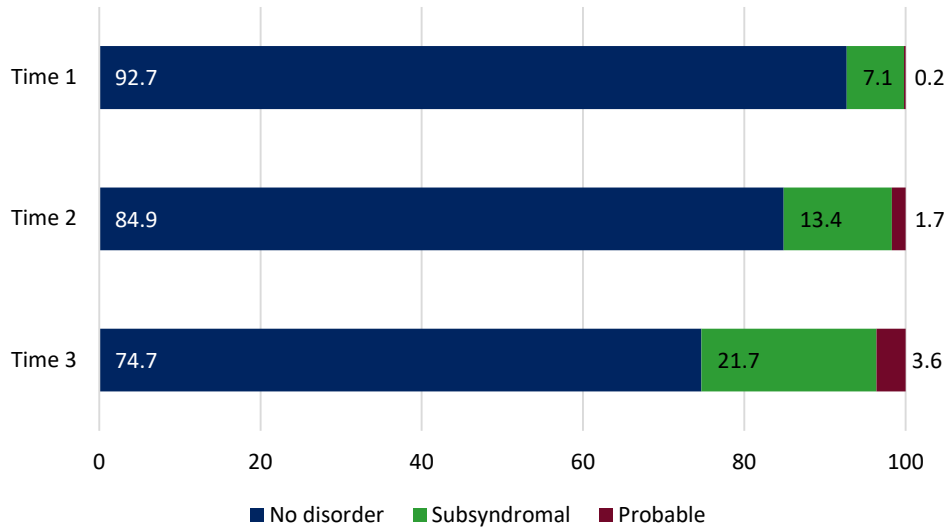
When considering the small proportion of participants who scored above the screening cut-off at Time 1 (7.3%), 7.1% were subsyndromal and a further 0.2% exhibited symptomatology indicative of probable PTSD. The proportion of participants who were subsyndromal increased to 13.4% at Time 2 and increased again to 21.7% at Time 3.

The proportion of participants in the MEAO Deployed Cohort with probable PTSD increased steadily from Time 1 through to Time 3 (Time 1, 0.2%; Time 2, 1.7%; Time 3, 3.6%), although the numbers are very low.

4.1.4   Alcohol use and problem drinking (AUDIT)

This section presents a detailed summary of the pattern of self-reported alcohol use and problem drinking reported by the MEAO Deployed Cohort longitudinally across the three-time points – the MEAO Prospective Study pre-deployment assessment (Time 1), the MEAO Prospective Study post-deployment assessment (Time 2) and the Impact of Combat Study five-year follow-up (Time 3).

The AUDIT (Saunders et al., 1993) is a brief self-report instrument that is widely used in epidemiological and clinical practice for defining at-risk patterns of drinking. It was developed by the World Health Organization for the primary care setting after an extensive six-nation validation trial that included Australia (Babor et al., 2001).

The AUDIT examines the quantity and frequency of alcohol consumption, possible symptoms of dependence, and reactions or problems related to alcohol. The first eight questions use a five-item continuous scale (scored 0 to 4) while the last two questions

use a three-item scale (scored 0, 2 or 4). A final score is reached by summing across all 10 questions.

The ADF has used the AUDIT as an educational, epidemiological and clinical tool since the start of the ADF Mental Health Strategy. It was officially recognised as a tool to '… identify people whose drinking may pose a risk to their health, or who are already experiencing alcohol related problems, including dependence' in *ADF Health Bulletin* number 15/03 (Defence Health Services, 2003). It has been part of the Post Operational Psychological Screen (POPS) process since its introduction in 1999 (Steele & Fogarty, 2017) and in 2010 was used in the ADF Mental Health Prevalence and Wellbeing Study to examine self-reported alcohol use and problems in the entire ADF.

In addition to mean AUDIT scores, an optimal screening cut-off of 8 (subsyndromal disorder) and an optimal epidemiological cut-off of 20 (probable disorder) were used. These cut-offs were derived from the 2010 Regular ADF Mental Health Prevalence and Wellbeing Study.

Table 4.4 and Figure 4.7 show AUDIT data on alcohol use and problem drinking in the MEAO Deployed Cohort over time. While there was a significant increase in mean AUDIT scores during the period ($F(2,414) = 6.72$, $p = 0.002$), this was very small. Mean AUDIT scores were the same at Time 1 and Time 2 (M = 6.3, SE = 0.2) and were very similar at Time 3 (M = 6.6, SE = 0.2).

Table 4.4 and Figure 4.8 show data on alcohol use and problem drinking status in the MEAO Deployed Cohort over time. When proportions were examined according to screening and epidemiological cut-off scores, the following patterns emerged. Almost three-quarters of the MEAO Deployed Cohort fell below both the screening and the epidemiological cut-off points at Time 1 (71.2%) and Time 2 (72.1%); the proportion reduced slightly at Time 3 (67.5%).

Table 4.4   Alcohol use and problem drinking (AUDIT) in the MEAO Deployed Cohort (n = 416) over time

	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
No disorder (below both screening and epi cut-offs)	296	71.2 (66.8–75.5)	300	72.1 (67.8–76.4)	281	67.5 (63.0–72.0)
Subsyndromal (above screening cut-off but below epi cut-off)	117	28.1 (23.8–32.4)	108	26.0 (21.7–30.2)	123	29.6 (25.2–34.0)
Probable disorder (above both screening and epi cut-offs)	3	0.7 (0.0–1.5)	8	1.9 (0.6–3.2)	12	2.9 (1.3–4.5)
Mean score (M, SE)		6.3 (0.2)		6.3 (0.2)		6.6 (0.3)

Note: Total scores for Prospective Study included only those with scores on all variables. Impact of Combat had mean scores imputed for missings.

Figure 4.7   Mean alcohol use and problem drinking in the MEAO Deployed Cohort over time
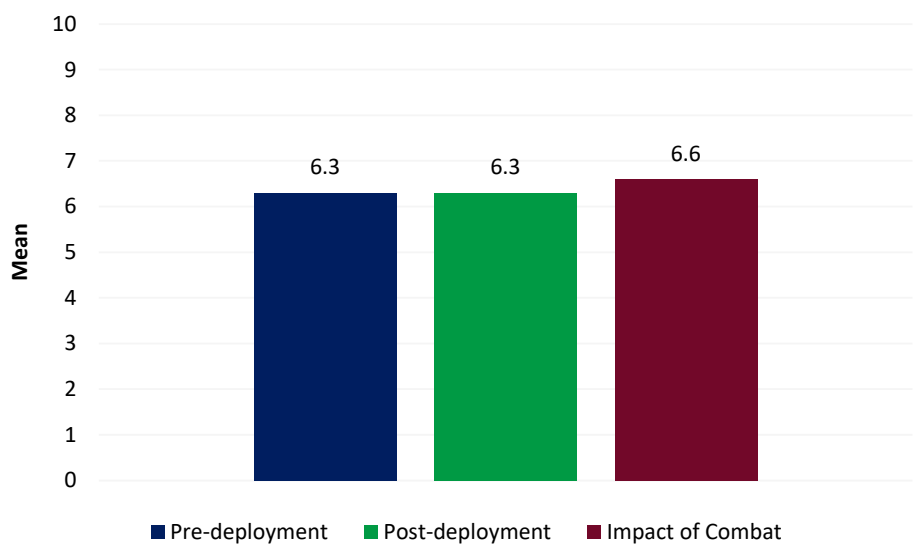
Figure 4.8   Alcohol use and problem drinking status in the MEAO Deployed Cohort over time
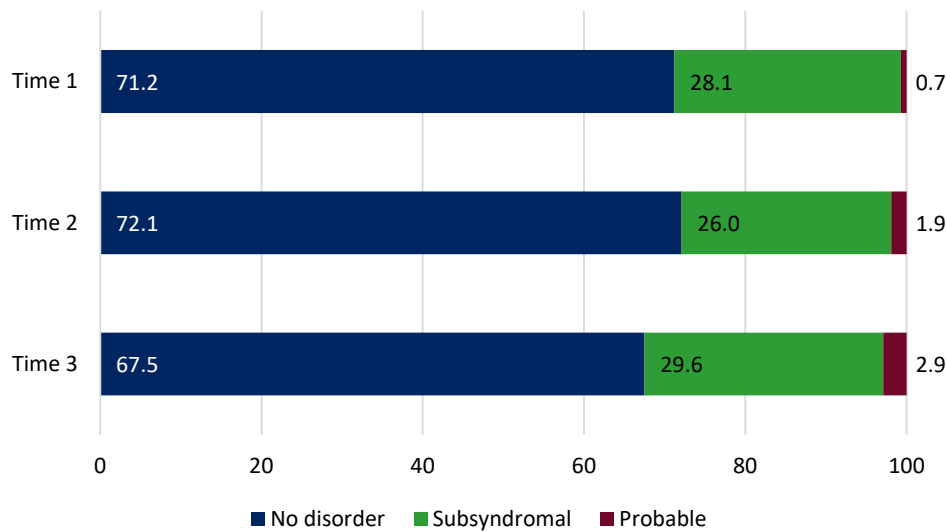
At Time 1, 28.8% of the MEAO Deployed Cohort scored above the screening cut-off. The overwhelming majority of these individuals reported subsyndromal symptom levels (28.1%) and a further 0.7% reported symptom levels indicative of probable

disorder. The proportion of individuals with subsyndromal symptomatology was relatively stable at Time 2 (26.0%) and Time 3 (29.6%).

The proportion of the MEAO Deployed Cohort with symptom levels indicating probable alcohol disorder, although low, increased over time (Time 1, 0.7%; Time 2, 1.9%; Time 3, 2.9%).

4.1.5   Anger symptoms (DAR-5)

This section summarises the anger symptoms reported by the MEAO Deployed Cohort longitudinally across the three time points – the MEAO Prospective Study pre-deployment assessment (Time 1), the MEAO Prospective Study post-deployment assessment (Time 2) and the Impact of Combat Study five-year follow-up (Time 3).

The five-item Dimensions of Anger Reaction Scale (Forbes et al., 2004) assesses anger frequency, intensity and duration and anger's perceived negative impact on social relationships, as rated over the preceding four weeks. Items are summed to create a total score (range 5 to 25), with higher scores indicating a higher frequency of anger. This scale has been used with Australian Vietnam veterans and US Afghanistan and Iraq veterans and shows strong uni-dimensionality and high levels of internal consistency and criterion validity (Forbes et al., 2004).

Responders were instructed to rate the amount of time they had experienced each of the five symptoms of anger over the preceding four weeks on a five-point scale ranging from 1 'none of the time' to 5 'all of the time'. In addition to the total score, a mean score for each of the individual anger items is presented as well as a cut-off of 12 to indicate problematic anger. There are no screening or epidemiological cut-offs for this measure.

Table 4.5 shows mean anger symptoms and the proportion of people with problematic anger on the DAR-5 in the MEAO Deployed Cohort over time. There was a significant increase in mean DAR-5 scores over time ($F(2,420) = 47.70$, $p < .0001$). Total mean anger scores increased at each time point (Time 1, M = 6.7, SE = 0.1; Time 2, M = 7.3, SE = 0.2; Time 3, M = 8.5, SE = 0.2). Figure 4.9 illustrates this.

The proportion of participants who had problematic anger also increased steadily from Time 1 through to Time 3 (Time 1, 5.5%; Time 2, 11.6%; Time 3, 19.2%).

Table 4.5   Mean anger symptoms and proportion with problem anger (DAR-5) in the MEAO Deployed Cohort (n = 422) over time

Anger symptoms	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	M	SE	M	SE	M	SE
Mean score	6.7	0.1	7.3	0.2	8.5	0.2
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Problem anger (total ≥ 12)	23	5.5 (3.3–7.6)	49	11.6 (8.6–14.7)	81	19.2 (15.4–23.0)

Note: Where an SE is reported as 0.0, note that this is the rounded figure (rounded to 0).

Figure 4.9   Mean anger symptoms in the MEAO Deployed Cohort over time
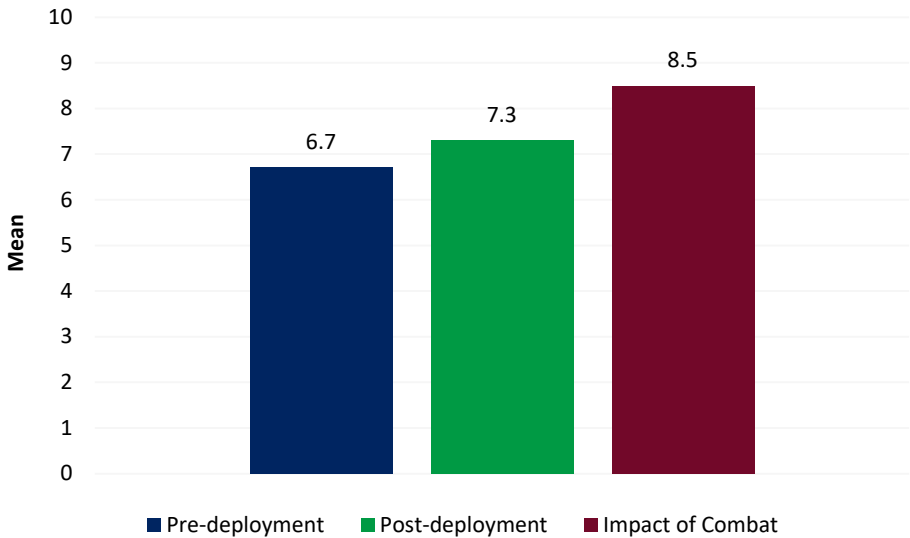
4.1.6   Suicidality

This section summarises suicidality (suicidal ideation, plans and attempts) reported by the MEAO Deployed Cohort longitudinally across the three separate time points – the MEAO Prospective Study pre-deployment assessment (Time 1), the MEAO Prospective Study post-deployment assessment (Time 2) and the Impact of Combat Study five-year follow-up (Time 3).

Twelve-month self-reported suicidal ideation and behaviour in the population was examined using four questions:

- *Suicidal ideation.* In the last 12 months, have you ever felt that your life was not worth living?

- *Suicidal ideation.* In the last 12 months, have you ever felt so low that you thought about committing suicide?

- *Suicide plan.* In the last 12 months, have you made a suicide plan?

- *Suicide attempt.* In the last 12 months, have you attempted suicide?

In addition to presenting the proportion of the cohort who reported each individual item, the proportion reporting any of the items is also shown. There are no screening or epidemiological cut-offs for this measure.

Table 4.6 shows data for suicidality over time in the MEAO Deployed Cohort. The proportion of participants who endorsed any of the suicide items listed in the survey ('any suicidality') increased from Time 1 (2.2%) to Time 2 (3.6%) and increased dramatically at Time 3, to 12.7%. A total of 1.9% of participants reported that their life was not worth living at Time 1; this proportion almost doubled (3.6%) at Time 2 and noticeably increased at Time 3, to 12.2%. A smaller proportion of participants reported that they felt so low that they thought about committing suicide at Time 1 (1.0%); the proportion increased slightly at Time 2 (1.4%) and notably at Time 3 (7.7%). Although no one reported formulating a suicide plan or attempting suicide at either Time 1 or Time 2, at Time 3 2.6% of members reported making a suicide plan and 1.0% of members reported attempting suicide.

Table 4.6   Suicidality in the MEAO Deployed Cohort (n = 417) over time

Suicidality	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Felt life not worth living	8	1.9 (0.6–3.2)	15	3.6 (1.8–5.4)	51	12.2 (9.1–15.4)
Felt so low thought about committing suicide	4	1.0 (0.0–1.9)	6	1.4 (0.3–2.6)	32	7.7 (5.1–10.2)
Made a suicide plan	0	0.0	0	0.0	11	2.6 (1.1–4.2)
Attempted suicide	0	0.0	0	0.0	4	1.0 (0.0–1.9)
Any suicidality	9	2.2 (0.8–3.6)	15	3.6 (1.8–5.4)	53	12.7 (9.5–15.9)

4.1.7   Lifetime and 12-month CIDI mental disorders

This section examines lifetime and 12-month ICD-10 mental disorders in the MEAO Deployed Cohort according to whether members had transitioned or remained in the Regular ADF in 2015.

The section shows rates for three classes of ICD-10 mental disorder – anxiety disorder, affective disorder and alcohol disorder. PTSD is separated out in order to demonstrate how it differs from other anxiety disorders. PTSD is classed with anxiety disorders within the ICD-10 classification system, but it is now a separate category in the

Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) (McFarlane, 2014).

Table 4.7 shows the lifetime and 12-month raw rates of ICD-10 anxiety disorders, affective disorders, alcohol disorders and PTSD for the MEAO Deployed Cohort according to whether members had transitioned or remained in the Regular ADF in 2015. Of those who had transitioned, 79.2% met criteria for any ICD-10 mental disorder in their lifetime, compared with 66.7% of those who remained in the Regular ADF. When considering 12-month disorder rates, half of those who had transitioned compared with 21.9% of those who remained in the Regular ADF met criteria for any mental disorder class in the preceding 12 months.

Alcohol (59.7%) and anxiety disorders (55.6%) were the most prevalent lifetime disorder classes for members of the cohort who had transitioned, with lower rates of affective disorder (37.5%) and PTSD (29.2%). This was also the case for those who remained in the Regular ADF: 47.4% of participants reported any alcohol disorder and 32.5% reported any anxiety disorder, the rates for both affective disorder (18.4%) and PTSD (13.2%) being lower. Members who had transitioned reported higher rates of each disorder class compared with those who remained in the Regular ADF.

Anxiety disorder (41.7%) was the most prevalent 12-month disorder class among members who had transitioned, with lower rates of affective disorder (19.4%) and alcohol disorder (16.7%). A total of 22.2% of those who had transitioned met criteria for 12-month PTSD compared with only 7.0% among those who remained in the Regular ADF. The most prevalent 12-month disorder class among members who remained in the Regular ADF was anxiety disorder (18.4%), with lower rates of affective disorder (7.0%) and alcohol disorder (4.4%). Again, those who had transitioned reported higher rates of each 12-month disorder class compared with those who remained in the Regular ADF.

Affective disorders

This section looks at rates of lifetime and 12-month ICD-10 affective disorder in the MEAO Deployed Cohort. Three types of affective disorder were included:

- *Depressive episodes.* These are a characteristic of a major depressive disorder and require that an individual has suffered from depressed mood lasting a minimum of two weeks, with associated symptoms or feelings of worthlessness, lack of appetite, difficulty with memory, reduced energy, low self-esteem, concentration problems and suicidal thoughts. Depressive episodes can be mild, moderate or severe. All three are included under the same heading. Hierarchy rules were applied to depressive episodes such that a person could not have met criteria for a hypomanic or manic episode.

- *Dysthymia.* This is a chronic or pervasive disturbance of mood lasting several years that is not sufficiently severe or in which the depressive episodes are not sufficiently prolonged to warrant a diagnosis of a depressive disorder. Hierarchy rules were applied to dysthymia such that to have this disorder a person could not have met criteria for a hypomanic or manic episode and could not have reported episodes of severe or moderate depression in the first two years of dysthymia.

- *Bipolar affective disorder.* This is associated with fluctuations of mood that are significantly disturbed. The fluctuations are markedly elevated on some occasions (hypomania or mania) and can be markedly lowered on others (depressive episodes). A diagnosis of bipolar affective disorder was applied in this study if an individual met criteria for mania or hypomania in the preceding 12 months, as follows:

  – Hypomanic episodes last at least four consecutive days and are considered abnormal to the individual. These episodes are characterised by increased activity, talkativeness, elevated mood, disrupted concentration, decreased need for sleep and disrupted judgment manifest as risk taking (for example, mild spending sprees). In a subgroup of people this disorder is particularly characterised by irritability. To meet criteria for the 'with hierarchy' version, the person cannot have met criteria for an episode of mania.

  – Mania is similar to hypomania but is more severe. Lasting slightly longer (a minimum of a week), the episodes often lead to severe interference with personal functioning. In addition to the symptoms outlined for hypomania, mania is often associated with feelings of grandiosity, marked sexual indiscretion and racing thoughts.

Table 4.8 summarises the lifetime and 12-month rates of ICD-10 affective disorders in the MEAO Deployed Cohort according to whether or not members of the cohort had transitioned or remained in the Regular ADF. Members who had transitioned reported higher rates of every lifetime affective disorder class compared with those who remained in the Regular ADF.

In the case of lifetime affective disorders overall, as was expected members who had transitioned reported higher rates of any lifetime affective disorder (37%) compared with those who remained in the Regular ADF (18.4%).

The most common lifetime affective disorder class for the MEAO Deployed Cohort – regardless of whether they had transitioned or remained in the Regular ADF – was depressive episodes (20.8% and 11.4% respectively); this was followed by bipolar affective disorder (Transitioned ADF, 15.3%; 2015 Regular ADF, 7.0%) and dysthymia (Transitioned ADF, 1.4%; 2015 Regular ADF, 0.0%).

Table 4.7   Prevalence of lifetime and 12-month ICD-10 anxiety, affective and alcohol disorders in MEAO Deployed Cohort

	Lifetime						12-month					
	Transitioned ADF n = 72		2015 Regular ADF n = 114		Total n = 186		Transitioned ADF n = 72		2015 Regular ADF n = 114		Total n = 186	
ICD-10 disorder	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)
Anxiety disorder (incl PTSD)	40	55.6 (44.1–67.0)	37	32.5 (23.9–41.1)	77	41.4 (34.3–48.5)	30	41.7 (30.3–53.1)	21	18.4 (11.3–25.5)	51	27.4 (21.0–33.8)
Affective disorder	27	37.5 (26.3–48.7)	21	18.4 (11.3–25.5)	48	25.8 (19.5–32.1)	14	19.4 (10.3–28.6)	8	7.0 (2.3–11.7)	22	11.8 (7.2–16.5)
Alcohol disorder	43	59.7 (48.4–71.1)	54	47.4 (38.2–56.5)	97	52.2 (45.0–59.3)	12	16.7 (8.1–25.3)	5	4.4 (0.6–8.1)	17	9.1 (5.0–13.3)
PTSD	21	29.2 (18.7–39.7)	15	13.2 (7.0–19.4)	36	19.4 (13.7–25.0)	16	22.2 (12.6–31.8)	8	7.0 (2.3–11.7)	24	12.9 (8.1–17.7)
Any disorder	57	79.2 (69.8–88.5)	76	66.7 (58.0–75.3)	133	71.5 (65.0–78.0)	36	50.0 (38.5–61.5)	25	21.9 (14.3–29.5)	61	32.8 (26.0–39.5)

Note: A description of each of the ICD-10 disorder classes is provided in the glossary.

Table 4.8   Lifetime and 12-month ICD-10 affective disorders in MEAO Deployed Cohort

	Lifetime						12-month					
	Transitioned ADF n = 72		2015 Regular ADF n = 114		Total n = 186		Transitioned ADF n = 72		2015 Regular ADF n = 114		Total n = 186	
ICD-10 affective disorder	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)
Depressive episodes	15	20.8 (11.5–30.2)	13	11.4 (5.6–17.2)	28	15.1 (9.9–20.2)	7	9.7 (2.9–16.6)	5	4.4 (0.6–8.1)	12	6.5 (2.9–10.0)
Dysthymia	1	1.4 (0.0–4.1)	0	0.0	1	0.5 (0.0–1.6)	1	1.4 (0.0–4.1)	0	0.0	1	0.5 (0.0–1.6)
Bipolar affective disorder	11	15.3 (7.0–23.6)	8	7.0 (2.3–11.7)	19	10.2 (5.9–14.6)	6	8.3 (1.9–14.7)	3	2.6 (0.0–5.6)	9	4.8 (1.8–7.9)
Any affective disorder	27	37.5 (26.3–48.7)	21	18.4 (11.3–25.5)	48	25.8 (19.5–32.1)	14	19.4 (10.3–28.6)	8	7.0 (2.3–11.7)	22	11.8 (7.2–16.5)

Note: A description of each of the ICD-10 disorder classes is provided in the glossary.

As with the pattern observed for lifetime affective disorders, members of the cohort who had transitioned reported higher rates of every 12-month disorder class listed, as well as 12-month affective disorder overall, when compared with those who remained in the Regular ADF (19.4 vs 7.0%). Again, the most common 12-month affective disorder class for both groups was depressive episodes (Transitioned ADF, 9.7%; 2015 Regular ADF, 4.4%); this was followed by bipolar affective disorder (Transitioned ADF, 8.3%; 2015 Regular ADF, 2.6%) and very low rates of dysthymia (Transitioned ADF, 1.4%; 2015 Regular ADF,: 0.0%).

Anxiety disorders

This section looks at the rates of lifetime and 12-month ICD-10 anxiety disorders in the MEAO Deployed Cohort. Eight types of anxiety disorders were examined:

- *Panic attack.* This involves a sudden onset of extreme fear or anxiety, often accompanied by palpitations, chest pain, choking sensations, dizziness, and sometimes feelings of unreality, fear of dying, losing control or going mad.

- *Panic disorder.* This involves regular panic attacks that are unpredictable in nature.

- *Agoraphobia.* This is characterised by a marked fear or avoidance of things such as crowds, public places, travelling alone or travelling away from home. It is accompanied by palpitations, sweating, shaking or dry mouth, as well as other anxiety symptoms such as chest pain, choking sensations, dizziness, and sometimes feelings of unreality, fear of dying, losing control or going mad.

- *Social phobia.* This involves a marked fear or avoidance of being the centre of attention or being in situations where it is possible to behave in a humiliating or embarrassing way. It is accompanied by anxiety symptoms, as well as either blushing, fear of vomiting, or fear of defecation or micturition.

- *Specific phobia.* This is characterised by a marked fear or avoidance of a specific object or situation – for example, birds, insects, heights, thunder, flying, small enclosed spaces, the sight of blood or injury, injections, dentists or hospitals. It is accompanied by anxiety symptoms such as those described for agoraphobia.

- *Generalised anxiety disorder.* This involves generalised and persistent worry, anxiety or apprehension about everyday events and activities. It lasts a minimum of six months and is accompanied by anxiety symptoms such as those described for agoraphobia. Other possible symptoms are symptoms of tension (such as an inability to relax and muscle tension) and other non-specific symptoms such as irritability and difficulty in concentrating. Hierarchy rules were applied to generalised anxiety disorder, such that, to have this disorder, the disorder could not be exclusively associated with social phobia or specific phobia, exclusively

occur within the duration of panic disorder, or exclusively occur within the duration of (and be exclusively associated with) OCD.

- *Obsessive–compulsive disorder.* OCD is characterised by obsessional thoughts (ideas, images, impulses) or compulsive acts (ritualised behaviour). These thoughts and acts are often distressing and typically cannot be avoided, despite the sufferer recognising their ineffectiveness.

- *Posttraumatic stress disorder.* This is characterised by a stress reaction to an exceptionally threatening or traumatic event that would cause pervasive distress in almost anyone. Symptoms are grouped into three categories: re-experiencing memories or flashbacks, avoidance symptoms, and either hyperarousal (increased arousal and sensitivity to cues) or an inability to recall important parts of the experience.

Table 4.9 shows the lifetime and 12-month rates of ICD-10 anxiety disorders in the MEAO Deployed Cohort according to whether members had transitioned or remained in the Regular ADF. With the exception of panic disorder, members who had transitioned reported higher rates of every lifetime disorder class compared with those who remained in the Regular ADF. As expected, this was the trend overall too, with those who had transitioned reporting higher rates of any lifetime anxiety disorder (55.6%) compared with those who remained in the Regular ADF (32.5%).

The most common lifetime anxiety disorder class for both groups was panic attack (Transitioned ADF, 33.3%; 2015 Regular ADF, 25.4%); this was followed by PTSD (Transitioned ADF, 29.2%; 2015 Regular ADF, 13.2%). While over a quarter of members who had transitioned (27.8%) reported agoraphobia, only 8.8% of those who remained in the Regular ADF reported this disorder. Similarly, 18.1% of those who had transitioned reported social phobia compared with only 8.8% of those who remained in the Regular ADF. The least common lifetime anxiety disorder for cohort members who had transitioned was generalised anxiety disorder (4.2%), which was also extremely uncommon for those who remained in the Regular ADF (1.8%). The least common lifetime anxiety disorder class for cohort members who remained in the Regular ADF was obsessive–compulsive disorder: no one reported this disorder compared with 9.7% of those who had transitioned.

A total of 41.7% of cohort members who had transitioned met ICD-10 criteria for any anxiety disorder in the preceding 12 months; this compares with only 18.4% of those who remained in the Regular ADF. The most common disorder category for those who had transitioned was PTSD (22.2%); this was followed by panic attack (15.3%) and agoraphobia (12.5%). Rates of 12-month anxiety disorders among those who remained in the Regular ADF were generally quite low; the most commonly reported 12-month

anxiety disorder categories for these cohort members were panic attack (10.5%) and PTSD (7.0%).

Alcohol disorders

This section looks at rates of lifetime and 12-month ICD-10 alcohol disorder in the MEAO Deployed Cohort according to whether members had transitioned or remained in the Regular ADF. Two types of alcohol disorder were included:

- *Alcohol harmful use.* This is characterised by a pattern of alcohol use that is damaging to health. The damage can be physical or mental – in the absence of a diagnosis of dependence syndrome (ICD-10). Diagnosis requires high levels of alcohol consumption that is damaging to the person's physical or mental health. Each participant was initially asked if they consumed 12 or more standard alcoholic drinks in a 12-month period. If so, they were then asked questions about their level of consumption. A diagnosis of alcohol harmful use was applied if the alcohol interfered with work or other responsibilities, caused arguments with family or friends, was consumed in a situation where the person could be hurt or resulted in being stopped or arrested by police, or if the participant continued to consume alcohol despite experiencing social or interpersonal problems related to their drinking during the preceding 12 months. A person could not meet the criteria for alcohol harmful use if they met the criteria for alcohol dependence. Hierarchy rules were applied to alcohol harmful use, such that to have this disorder a person could not have met criteria for alcohol dependence during the same period (that is, the duration of the two disorders must not overlap). Hence, participants that met criteria for both alcohol harmful use and alcohol dependence in the same period appear only under alcohol dependence when using hierarchy rules.

- *Alcohol dependence.* This entails a cluster of cognitive, behavioural and physiological characteristics indicating that a person continues to use alcohol despite significant alcohol-related problems (ICD-10). It is characterised by increased prioritisation of alcohol in a person's life. The defining feature of alcohol dependence is a strong, overwhelming desire to use alcohol despite experiencing several associated problems. A diagnosis was given if the person reported three or more of the following symptoms in the preceding 12 months:

    – a strong and irresistible urge to consume alcohol

    – a tolerance of the effects of alcohol

    – an inability to stop or reduce alcohol consumption

    – withdrawal symptoms on cessation or reduction of alcohol intake

    – continuing to drink despite it causing emotional or physical problems

    – a reduction in important activities because of drinking or in order to drink.

Table 4.10 reports the patterns of alcohol harmful use and dependence in MEAO Deployed Cohort members who had transitioned and those who remained in the Regular ADF according to ICD-10 criteria. The rate of alcohol harmful use was comparable for both populations (Transitioned ADF, 38.9%; 2015 Regular ADF, 37.7%) but the rate of alcohol dependence was higher among those who had transitioned (20.8%) compared with those who remained in the Regular ADF (11.4%). When considering lifetime alcohol disorders overall, those who had transitioned reported higher rates of any lifetime alcohol disorder (59.7%) compared with those who remained in the Regular ADF (47.4%).

Although the rates of both 12-month alcohol disorder classes were fairly low for the two populations, alcohol harmful use and alcohol dependence were more commonly reported by members of the cohort who had transitioned. Those who had transitioned also reported higher rates of any 12-month alcohol disorder (16.7%) compared with those who remained in the Regular ADF (4.4%). The most common 12-month alcohol disorder class for both populations was alcohol dependence (Transitioned ADF, 9.7%; 2015 Regular ADF, 3.5%), followed by 12-month alcohol harmful use (Transitioned ADF, 6.9%; 2015 Regular ADF, 0.9%).

4.2 Physical health outcomes

4.2.1 Health symptoms

This section examines self-reported health symptoms among the MEAO Deployed Cohort.

General health symptoms were assessed using a 67-item self-report checklist of health symptoms experienced in the preceding month. The checklist was adapted from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015) for use in the MEAO Prospective Health Study (Davy et al., 2012) and the Census Study (Dobson et al., 2012). Items included respiratory, cardiovascular, musculoskeletal, dermatological, gastrointestinal, genitourinary, neurological and cognitive symptoms.

Participants were asked to identify whether they had experienced each of the listed symptoms in the preceding month and to indicate whether the symptoms were mild, moderate or severe in nature. For the purpose of this report a mean score was calculated and used.

Table 4.11 and Figure 4.10 show the mean number of health symptoms in the MEAO Deployed Cohort over time. There was a significant increase in mean health symptoms over time ($F_{(2,422)} = 66.51$, $p < .0001$). The mean number of symptoms reported by participants increased from Time 1 (M = 7.7, SE = 0.4) to Time 2 (M = 10.4, SE = 0.5) and was higher again at Time 3 (M = 12.8, SE = 0.5).

Table 4.9   Lifetime and 12-month ICD-10 anxiety disorders in MEAO Deployed Cohort

| | Lifetime | | | | | | 12-month | | | | | |
| | Transitioned ADF n = 72 | | 2015 Regular ADF n = 114 | | Total n = 186 | | Transitioned ADF n = 72 | | 2015 Regular ADF n = 114 | | Total n = 186 | |
ICD-10 anxiety disorder	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)
Panic attack	24	33.3 (22.4–44.2)	29	25.4 (17.4–33.4)	53	28.5 (22.0–35.0)	11	15.3 (7.0–23.6)	12	10.5 (4.9–16.2)	23	12.4 (7.6–17.1)
Panic disorder	4	5.6 (0.3–10.8)	7	6.1 (1.7–10.5)	11	5.9 (2.5–9.3)	3	4.2 (0.0–8.8)	5	4.4 (0.6–8.1)	8	4.3 (1.4–7.2)
Agoraphobia	20	27.8 (17.4–38.1)	10	8.8 (3.6–14.0)	30	16.1 (10.8–21.4)	9	12.5 (4.9–20.1)	5	4.4 (0.6–8.1)	14	7.5 (3.7–11.3)
Social phobia	13	18.1 (9.2–26.9)	10	8.8 (3.6–14.0)	23	12.4 (7.6–17.1)	7	9.7 (2.9–16.6)	3	2.6 (0.0–5.6)	10	5.4 (2.1–8.6)
Specific phobia	7	9.7 (2.9–16.6)	9	7.9 (2.9–12.8)	16	8.6 (4.6–12.6)	4	5.6 (0.3–10.8)	5	4.4 (0.6–8.1)	9	4.8 (1.8–7.9)
Generalised anxiety disorder	3	4.2 (0.0–8.8)	2	1.8 (0.0–4.2)	5	2.7 (0.4–5.0)	1	1.4 (0.0–4.1)	1	0.9 (0.0–2.6)	2	1.1 (0.0–2.6)
Obsessive–compulsive disorder	7	9.7 (2.9–16.6)	0	0.0	7	3.8 (1.0–6.5)	5	6.9 (1.1–12.8)	0	0.0	5	2.7 (0.4–5.0)
Posttraumatic stress disorder	21	29.2 (18.7–39.7)	15	13.2 (7.0–19.4)	36	19.4 (13.7–25.0)	16	22.2 (12.6–31.8)	8	7.0 (2.3–11.7)	24	12.9 (8.1–17.7)
Any anxiety disorder	40	55.6 (44.1–67.0)	37	32.5 (23.9–41.1)	77	41.4 (34.3–48.5)	30	41.7 (30.3–53.1)	21	18.4 (11.3–25.5)	51	27.4 (21.0–33.8)

Note: A description of each of the ICD-10 disorder classes is provided in the glossary.

Table 4.10   Lifetime and 12-month ICD-10 alcohol disorders in MEAO Deployed Cohort

| | Lifetime | | | | | | 12-month | | | | | |
| | Transitioned ADF n = 72 | | 2015 Regular ADF n = 114 | | Total n = 186 | | Transitioned ADF n = 72 | | 2015 Regular ADF n = 114 | | Total n = 186 | |
ICD-10 alcohol disorder	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)
Alcohol harmful use	28	38.9 (27.6–50.1)	43	37.7 (28.8–46.6)	71	38.2 (31.2–45.2)	5	6.9 (1.1–12.8)	1	0.9 (0.0–2.6)	6	3.2 (0.7–5.8)
Alcohol dependence	15	20.8 (11.5–30.2)	13	11.4 (5.6–17.2)	28	15.1 (9.9–20.2)	7	9.7 (2.9–16.6)	4	3.5 (0.1–6.9)	11	5.9 (2.5–9.3)
Alcohol disorder	43	59.7 (48.4–71.1)	54	47.4 (38.2–56.5)	97	52.2 (45.0–59.3)	12	16.7 (8.1–25.3)	5	4.4 (0.6–8.1)	17	9.1 (5.0–13.3)

Note: A description of each of the ICD-10 disorder classes is provided in the glossary.

Table 4.11 Mean number of health symptoms in the MEAO Deployed Cohort (n = 424) over time

	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	M	SE	M	SE	M	SE
Mean number of conditions	7.7	0.4	10.4	0.5	12.8	0.5

Figure 4.10 Mean number of health symptoms in the MEAO Deployed Cohort over time
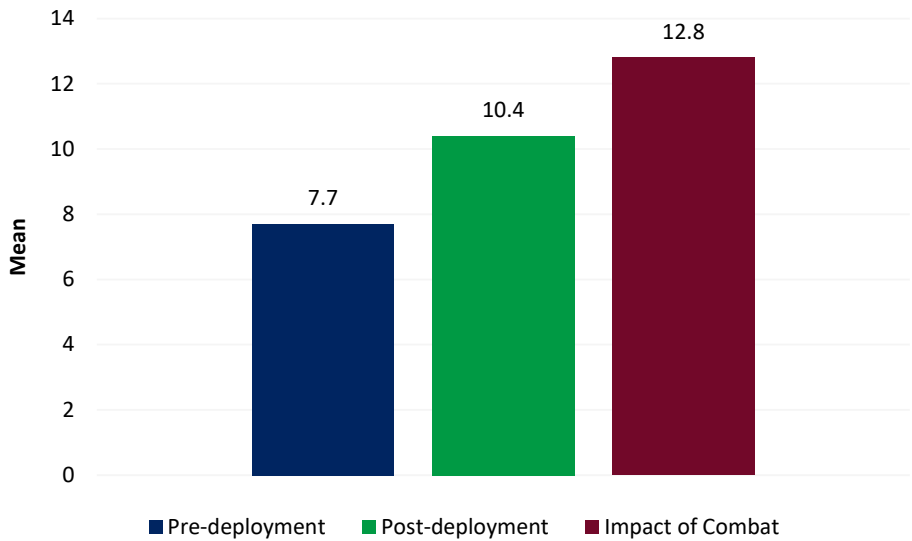
4.2.2 Pain intensity and disability

This section examines pain intensity and disability in the MEAO Deployed Cohort according to whether members had transitioned or remained in the Regular ADF.

Items assessing pain intensity and disability were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015). Participants were asked to answer a series of questions on a 10-point scale about their current pain, worst pain and average pain in the preceding six-month period. They were also asked to indicate how much their pain had interfered with their daily activities, their recreational and social activities, and their ability to work in the preceding six months.

On the basis of an algorithm developed by Von Korff et al. (1992), scores on these items were categorised into the following grades of pain intensity and disability:

- Grade 0 – 'pain free'

- Grade I – 'low disability – low intensity'

- Grade II – 'low disability – high intensity'

- Grade III – 'high disability – moderately limiting'

- Grade IV – 'high disability – severely limiting'.

Table 4.12 shows the proportion of responses for the pain intensity and disability grades in the MEAO Deployed Cohort according to whether members had transitioned or remained in the Regular ADF. Similar proportions of members who had transitioned (10.8%) and members who remained in the Regular ADF (10.0%) reported being pain free (Grade 0). The majority of participants from both populations reported experiencing Grade I pain intensity and disability (Transitioned ADF, 55.9%; 2015 Regular ADF, 62.6%). When considering the higher pain intensity and disability categories, although similar proportions of those who had transitioned and those who remained in the Regular ADF reported Grade III pain intensity and disability (9.7% and 10.6% respectively), a higher proportion of those who had transitioned (9.7%) reported the highest grade of pain intensity and disability (Grade IV) compared with only 5.9% of those who remained in the Regular ADF.

Table 4.12   Pain intensity and disability in Transitioned ADF and 2015 Regular ADF in the MEAO Deployed Cohort

Pain intensity and disability	Transitioned ADF n = 93		2015 Regular ADF n = 321		Total n = 414	
	n	%(95% CI)	n	%(95% CI)	n	%(95% CI)
Grade 0 – 'pain free'	10	10.8 (4.5–17.0)	32	10.0 (6.7–13.2)	42	10.1 (7.2–13.1)
Grade I – 'low disability – low intensity'	52	55.9 (45.8–66.0)	201	62.6 (57.3–67.9)	253	61.1 (56.4–65.8)
Grade II – 'low disability – high intensity'	13	14.0 (6.9–21.0)	35	10.9 (7.5–14.3)	48	11.6 (8.5–14.7)
Grade III – 'high disability – moderately limiting'	9	9.7 (3.7–15.7)	34	10.6 (7.2–14.0)	43	10.4 (7.4–13.3)
Grade IV – 'high disability – severely limiting'	9	9.7 (3.7–15.7)	19	5.9 (3.3–8.5)	28	6.8 (4.3–9.2)

4.2.3   Body mass index

This section looks at body mass index as an assessment of healthy weight in the MEAO Deployed Cohort at the three time points – the MEAO Prospective Study pre-deployment assessment (Time 1), the MEAO Prospective Study post-deployment assessment (Time 2), and the Impact of Combat Study five-year follow-up (Time 3).

BMI was calculated as a function of responders' self-reported weight and height – weight (kg)/(height (m)^2. On the basis of guidelines from the Australian Government Department of Health (Department of Health, 2017), BMI scores were categorised as underweight (<18.5 kg/m^2), normal (18.5–24.9 kg/m^2), pre-obese (25–29.9 kg/m^2), obese class 1 (30–34.9 kg/m^2), obese class 2 (35–39.9 kg/m^2) and obese class 3 (>40 kg/m^2).

Table 4.13 shows mean BMI scores and the proportion of participants within the MEAO Deployed Cohort who fell into each of the BMI categories over time. There were no significant differences in mean BMI over time. It was 26.4 at Time 1, 27.0 at Time 2 and 27.2 at Time 3 (see Figure 4.11).

Table 4.13   BMI in the MEAO Deployed Cohort (n = 95) over time

BMI category	Time 1 (Prospective pre-deployment)		Time 2 (Prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Underweight	0	0.0	0	0.0	0	0.0
Normal range	33	34.7 (25.2–44.3)	25	26.3 (17.5–35.2)	23	24.2 (15.6–32.8)
Pre-obese	51	53.7 (43.7–63.7)	56	58.9 (49.1–68.8)	63	66.3 (56.8–75.8)
Obese class 1	11	11.6 (5.1–18.0)	13	13.7 (6.8–20.6)	7	7.4 (2.1–12.6)
Obese class 2	0	0.0	1	1.1 (0.0–3.1)	1	1.1 (0.0–3.1)
Obese class 3	0	0.0	0	0.0	1	1.1 (0.0–3.1)
Mean score (M, SE)		26.4 (0.3		27.0 (0.3)		27.2 (0.5)

Figure 4.11   Mean BMI in the MEAO Deployed Cohort over time
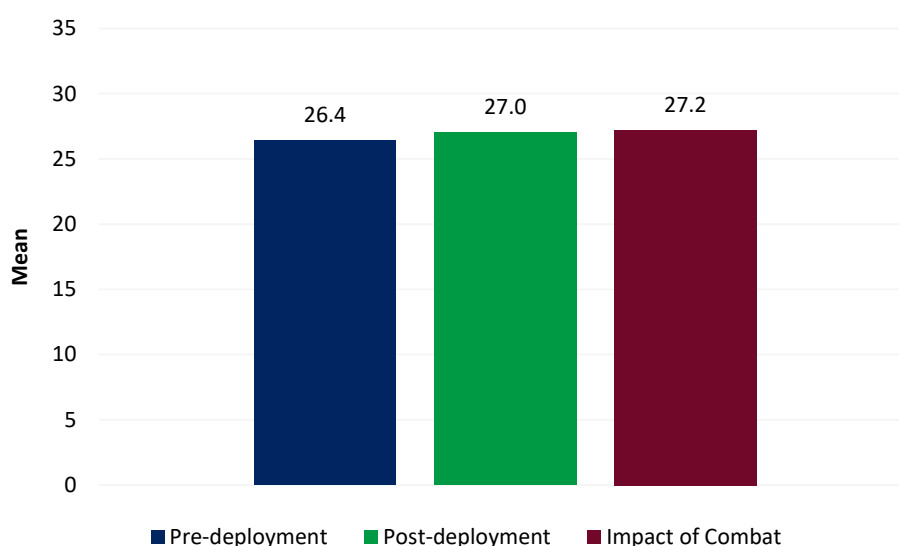
Over half (53.7%) of the participants fell within the pre-obese range at Time 1. The proportion increased to 58.9% at Time 2 and was higher still at Time 3 (66.3%). Just over one-third of participants (34.7%) were in the normal weight range at Time 1. This proportion decreased at Time 2, to 26.3%, and decreased again at Time 3, to 24.2%. In the case of the obese classifications, 11.6% of the MEAO Deployed Cohort were categorised as obese class 1; this proportion increased at Time 2 (13.7%) but,

interestingly, was lower at Time 3 (7.4%). No one fell into the obese class 2 and 3 categories at Time 1; at Time 2 still no one reported anthropometric measures equating to a BMI in the obese class 3 range but 1.1% of participants did fall into the obese class 2 category. At Time 3, 1.1% of participants fell into the obese class 2 and obese class 3 categories. No one fell into the underweight category at any time.

4.3 Biological outcomes

4.3.1 Demographic characteristics of biological testing responders at Time 3 (Impact of Combat Study)

The mean age of blood testing responders at Time 3 was 34.6 (SE = 1.1). Most were aged 28 to 37 years (42.2%), with 25.0% aged 18–27 years, 23.4% aged 38–47 years and 9.4% aged 48–57 years. No blood testing responders were aged over 58 years. Most responders were Army (95.3%), there being 4.7% Navy responders and no Air Force responders to blood testing. In terms of sex, most responders were male (95.3%). Non-Commissioned Officers made up 65.6% of blood testing responders; there were 25.0% from Other Ranks and 7.8% Officers (1.6% were missing).

4.3.2 Biological outcomes over time

Table 4.14 presents biological outcomes in the MEAO Deployed Cohort for the three time points. For the purpose of these analyses, because of the limited sample size, there is no stratification according to whether cohort members were transitioned or remained in the Regular ADF at Time 3.

Overall, only small changes were observed in the biological outcomes measured, and for a number of markers no changes were found, although there were some consistent patterns of change across groups of measures.

The liver enzyme gamma GT showed a significant change in mean scores over time ($F_{(1, 62)} = 3.33$, $p = 0.049$). Mean gamma GT increased from Time 1 (M = 20.6, SE = 1.7) to Time 2 (M = 25.2, SE = 2.5) and then decreased to fall in the middle of that range at Time 3 (M = 22.5, SE = 1.4).

Of the metabolic indices, although there was an overall significant increase in mean LDL cholesterol over time ($F_{(2, 54)} = 15.67$, $p < .0001$), it was relatively stable between Time 1 (M = 2.6, SE = 0.1) and Time 2 (M = 2.7, SE = 0.1), increasing slightly at Time 3 (M = 3.0, SE = 0.1). Mean total HDL cholesterol (Time 1, M = 1.3, SE = 0.0; Time 2, M = 1.3, SE = 0.0; Time 3, M = 1.3, SE = 0.0) and triglycerides (Time 1, M = 1.4, SE = 0.1; Time 2, M = 1.4, SE = 0.1; Time 3, M = 1.4, SE = 0.1) were not significantly different, remaining stable at all three time points.

There was a significant decrease in mean HbA1c over time ($F_{(2, 62)} = 35.25$, $p < .0001$), with a small decrease at each time point (Time 1, M = 5.5, SE = 0.0; Time 2, M = 5.3, SE

= 0.0; Time 3, M = 5.1, SE = 0.0). Mean random glucose did not significantly differ over time, remaining relatively stable (Time 1, M = 5.1, SE = 0.1; Time 2, M = 5.1, SE = 0.1; Time 3, M = 5.0, SE = 0.1).

Of the inflammatory markers, neither ESR nor mean white cell count showed a significant change over time. ESR showed a trend towards increasing between Time 2 and Time 3 (Time 1, M = 2.5, SE = 0.2; Time 2, M = 2.6, SE = 0.4; Time 3, M = 3.3, SE = 0.3), while mean white cell count was stable at all times (Time 1, M = 6.5, SE = 0.2; Time 2, M = 6.6, SE = 0.2; Time 3, M = 6.7, SE = 0.2).

Interleukin 1b (Time 1: M = 556.4, SE = 289.2; Time 2: M = 444.6, SE = 248.3; Time 3: M = 240.5, SE = 150.9), interleukin 10 (Time 1: M = 690.9, SE = 259.2; Time 2: M = 442.4, SE = 105.9; Time 3: M = 347.4, SE = 134.0), and SIL-2RA (Time 1: M = 1025.2, SE = 59.2; Time 2: M = 923.0, SE = 64.0; Time 3: M = 781.0, SE = 46.8) all decreased with time. SIL-2RA was the only marker to show a significant reduction with time ($F_{(2,42)}$ = 4.34, p = 0.016).

A number of markers (IL-6, TNF alpha, CRP, cortisol and BDNF) showed a pattern of an increase between Time 1 and Time 2 and a subsequent decrease at Time 3: mean interleukin 6 increased from Time 1 (M = 1025.1, SE = 427.5) to Time 2 (M = 1277.9, SE = 289.6) and then decreased substantially at Time 3 (M = 524.8, SE = 141.8). Mean TNF alpha increased from Time 1 (M = 4683.9, SE = 2437.0) to Time 2 (M = 5979.1, SE = 2331.2) and then decreased substantially at Time 3 (M = 2875.1, SE = 1193.1). Mean CRP increased from Time 1 (M = 0.8, SE = 0.2) to Time 2 (M = 1.6, SE = 0.4) and then decreased slightly at Time 3 (M = 1.4, SE = 0.3). Mean cortisol remained stable at Time 1 (M = 13776.1, SE = 1231.6) and Time 2 (M = 13024.2, SE = 1100.3) and then decreased at Time 3 (M = 10424.6, SE = 1141.2). BDNF increased from Time 1 (M = 38.7, SE = 1.4) to Time 2 (M = 42.0, SE = 1.8) and then decreased at Time 3 (M = 35.2, SE = 1.8). CRP and cortisol were the only markers that showed significant effects of time ($F_{(2,62)}$ = 5.09, p = 0.011 and $F_{(2,44)}$ = 4.03, p = 0.021 respectively).

Table 4.14   Biological outcomes in the MEAO Deployed Cohort over time

Biological outcomes	n	Time 1 (Prospective pre-deployment) n = 64		Time 2 (Prospective post-deployment) n = 64		Time 3 (Impact of Combat follow-up) n = 64	
		M	SE	M	SE	M	SE
Liver enzyme							
Gamma-glutamyl transferase (gamma GT)	64	20.6	1.7	25.2	2.5	22.5	1.4
Metabolic							
LDL cholesterol	56	2.6	0.1	2.7	0.1	3.0	0.1
HBA1C – NGSP	64	5.5	0.0	5.3	0.0	5.1	0.0
Random glucose	63	5.1	0.1	5.1	0.1	5.0	0.1
Total HDL cholesterol	57	1.3	0.0	1.3	0.0	1.3	0.0
Triglycerides	57	1.4	0.1	1.4	0.1	1.4	0.1
Inflammation							
Erythrocyte sedimentation rate (ESR)	60	2.5	0.2	2.6	0.4	3.3	0.3
White cell count	62	6.5	0.2	6.6	0.2	6.7	0.2
Interleukin 1b	44	556.4	289.2	444.6	248.3	240.5	150.9
Interleukin 6	45	1025.1	427.5	1277.9	289.6	524.8	141.8
Interleukin 10	45	690.9	259.2	442.4	105.9	347.4	134.0
TNF alpha	45	4683.9	2437.0	5979.1	2331.2	2875.1	1193.1
C-reactive protein (CRP)	64	0.8	0.2	1.6	0.4	1.4	0.3
Cortisol	46	13776.1	1231.6	13024.2	1100.3	10424.6	1141.2
SIL-2RA	44	1025.2	59.2	923.0	64.0	781.0	46.8
Other							
Brain-derived neurotrophic factor (BDNF)	42	38.7	1.4	42.0	1.8	35.2	1.8

5 Predicting long-term mental health in the MEAO Deployed Cohort

Psychological distress

- Previous deployments and career deployment exposure history were associated with elevated psychological distress at Time 3:

    - The more previous deployments cohort members had before the index deployment, the greater the likelihood of having elevated psychological distress at Time 3.

    - Members with high or very high levels of deployment exposure were three times more likely to have elevated psychological distress at Time 3 compared with those who had low or very low levels of exposure.

Posttraumatic stress

- The number of lifetime trauma exposure types and career deployment exposure history were associated with elevated posttraumatic stress symptoms at Time 3:

    - The greater the number of lifetime trauma exposure types at Time 1, the greater the likelihood of having elevated posttraumatic stress symptoms at Time 3.

    - Members with medium, high or very high levels of deployment exposure were three to five times more likely than those with very low exposure levels to have elevated posttraumatic stress symptoms at Time 3.

Physical health correlates of long-term mental health

- Cohort members with elevated psychological distress or posttraumatic stress symptoms at Time 3 reported greater numbers of physical health symptoms at all three time points, the difference increasing with time. The mean number of health symptoms reported by those with low psychological distress or posttraumatic stress symptoms remained relatively stable over time.

- Pro-inflammatory markers were lower at all three time points among members with elevated psychological distress or posttraumatic stress symptoms at Time 3. In contrast, cortisol levels were higher.

- Interestingly, levels of the anti-inflammatory marker interleukin 10 were higher among members with elevated posttraumatic stress symptoms at Time 3.

As Chapter 4 shows, over time there was a general decline in mental health among the MEAO Deployed Cohort. Although the vast majority of the cohort reported very low levels of mental disorder symptoms both before and after the index deployment (Time 1 and Time 2), symptoms had increased significantly by the 2015 follow-up (Time 3). A particular strength of a prospective longitudinal design such as that used for this study is the ability not only to document the course of health over time in a deployed cohort but also to examine the role of various baseline variables, as well as factors relating to an index deployment, in predicting this course.

For the purposes of this chapter, the primary outcome of interest was 2015 mental health status. Two variables were examined: posttraumatic stress symptoms (using the PCL-C) and psychological distress (using the K10). These were chosen because of their regular use as screening tools before and after deployment and more generally in the ADF. The outcomes also showed the greatest change between pre- and post-deployment in the preceding MEAO Prospective Health Study, and changes were associated with various deployment factors (Davy et al., 2012). Two outstanding questions from that earlier study were whether these low-level changes would progress or remit with the passage of time and whether factors at the initial measurement times could predict the longer term course of symptoms, allowing for the early identification of risk and, in turn, targets for early intervention.

In this chapter mental health status in 2015 was defined according to scores in 2015 (Time 3) on the PCL-C and K10. Because the MEAO Deployed Cohort is relatively small and the population extremely healthy, with very few cases of probable disorder, scores on the PCL-C and K10 were dichotomised to below screening and above screening according to cut-offs derived in the Mental Health Prevalence and Wellbeing Study (McFarlane et al., 2011b). Hence, an optimal screening cut-off of 17 was used for the K10 and 29 for the PCL-C. Those scoring above the screening cut-off are described as having elevated symptom levels and those below having low symptom levels. Separate models were run for psychological distress (K10) and posttraumatic stress symptoms (PCL-C).

Since the primary focus of this study is the impact of combat and the potential for early identification of risk for future mental health problems, where possible the predictors included in models were captured before and after index deployment (Time 1 and Time 2) and used to predict mental health status at Time 3.

5.1   Key predictors

5.1.1   Lifetime trauma

Lifetime exposure to trauma was examined at Time 1 using questions adapted from the CIDI (Composite International Diagnostic Interview) and modified by McFarlane et

al. (2011b). Participants were asked to indicate whether or not they had experienced each of the following traumatic events in their lifetime:

- direct combat

- life-threatening accident

- fire, flood, natural disaster

- witnessed someone killed or badly injured

- rape

- sexual molestation

- serious physical attack or assault

- threatened/harassed without weapon

- threatened with weapon/held captive/kidnapped

- tortured or victim of terrorists

- domestic violence

- witnessed domestic violence

- find dead body

- witnessed suicide/attempted suicide

- child abuse – physical

- child abuse – emotional

- any other stressful event.

The number of items endorsed was summed to create a total number of trauma types experienced by the participant (ranging from zero to 18).

5.1.2   Deployment exposures

Participants were asked about traumatic and environmental deployment exposures at Time 3 using items drawn from the MEAO Census Study (Dobson et al., 2012). They were presented with a list of 12 traumatic exposures and six environmental exposures and asked to indicate how many times they had experienced each one on deployment during their military career. Response categories were 0 'never', 1 'once', 2 '2–4 times', 3 '5–9 times' and 4 '10+ times'. Responders were also asked how many times they had experienced each exposure 'since 2011' to provide an indication of deployment exposures incurred in the years following the MEAO Prospective Study.

The following traumatic deployment exposure questions were asked:

- Seriously fear you would encounter an IED?

- Go on combat patrols/missions or participate in support convoys?

- Concerned about yourself or others (including allies) having an unauthorised discharge of a weapon?

- Clear/search buildings, caves, vessel, etc.?

- Come under fire (i.e. small arms or anti-aircraft fire, guided or directed mortar/artillery fire or missile attack, indirect fire (e.g. rocket attack), IED/EOD detonation, suicide bombing, landmine strike, small arms fire from an unknown enemy combatant)?

- In danger of being killed or injured?

- Have casualties among people close to you (i.e. were present or heard of a close friend, co-worker or loved one who had been injured or killed)?

- Handle or see dead bodies?

- Experience a threatening situation where you were unable to respond due to the rules of engagement?

- Witness human degradation and misery on a large scale?

- Discharge your weapon in direct combat?

- Believe your action or inaction resulted in someone being seriously injured or killed?

The six questions on environmental deployment exposures were as follows:

- Exposed to smoke and/or dust (i.e. smoke from fires/waste incineration/oil fire, dust storms, inhalation of fine dust or fibres, others' cigarette smoke)?

- Exposed to fumes or fuels (i.e. diesel exhaust, aviation/marine/automotive fuels, aircraft fumes)?

- Exposed to chemicals (i.e. toxic industrial chemicals, solvents, living area sprayed/fogged with chemicals)?

- Exposed to hazardous materials (i.e. non-iodising radiation, contact with chemical or biological weapons, contact with depleted uranium shells, exposed to ionising radiation or radioactive shells, use of NBS suit (not for training))?

- Exposed to local food or water (i.e. drank from local taps or wells, ate local food)?

- Exposed to noise (i.e. close to loud noises without hearing protection (e.g. explosions, weapon fire), exposed to loud noises for extended periods of time without hearing protection (e.g. machinery aircraft operations))?

Traumatic and environmental deployment exposures were summed separately and then categorised. Traumatic deployment exposures were categorised into very low (0–4), low (5–12), medium (13–22), high (23–31) and very high (32–48). Environmental deployment exposures were categorised into low (0–12), medium (13–17), high (18–20) and very high (21–24).

This chapter is divided into two sections: psychological distress and posttraumatic stress. The demographic, service-related and other characteristics of the cohort at Times 1 and 2 are first described according to mental disorder status at Time 3. The results of multivariate modelling of the effects of these characteristics on the mental health status of cohort members at Time 3 are then presented.

5.2   Psychological distress

5.2.1   Demographic and Service-related predictors of elevated psychological distress symptoms

Table 5.1 shows the demographic and Service characteristics of the MEAO Deployed Cohort at Time 1, according to psychological distress symptom status at Time 3. All analyses were adjusted for psychological distress symptom status at Time 1 and Time 2 and for transition status at Time 3.

The mean age of the MEAO Deployed Cohort did not differ between those who had low psychological distress symptoms (M = 33.7, SE = 0.6) and those who had elevated psychological distress symptoms at Time 3 (M = 32.1, SE = 0.9).

There was no significant difference in the proportions of males and females with elevated psychological distress at Time 3 (29.4% vs 23.3%).

There was a significant effect of rank on the likelihood of having elevated psychological distress at Time 3. Those who were Other Ranks at the time of the index deployment were more likely than Officers to have elevated psychological distress at Time 3 (38.9% vs 20.2%; OR 2.54, 95% CI 1.26, 5.12). A higher proportion of Non-Commissioned Officers than Officers had elevated psychological distress at Time 3, although the difference was not significant (27.9% vs 20.2%).

The proportion of MEAO Deployed Cohort members with elevated psychological distress at Time 3 was similar across the Services. Army had the highest proportion (31.4%), followed by Navy (26.3%) then Air Force (23.2%). Only the difference between Army and Air Force was significant (OR 1.78, 95% CI 1.00, 3.17).

There was no significant difference in length of military service reported at Time 1 between those who had low as opposed to elevated psychological distress at Time 3 (M = 11.9, SE = 0.6 vs M = 10.0, SE = 0.8). There were also no significant differences in

the likelihood of elevated psychological distress at Time 3 between those who had never deployed compared with those who had deployment experience before the index deployment (24.5% vs 30.7%). There was, however, an association between the number of previous deployments at Time 1 and the likelihood of elevated psychological distress at Time 3 (OR 1.10, 95% CI 1.01, 1.19).

There was no association between the number of lifetime trauma types reported by MEAO Deployed Cohort members at Time 1 and the likelihood of reporting elevated psychological distress symptoms at Time 3 (M = 2.6, SE = 0.2 vs M = 3.3, SE = 0.3).

Table 5.1   **Demographic and Service characteristics of the MEAO Deployed Cohort at Time 1, according to psychological distress symptom status at Time 3**

	Time 3: Impact of Combat Study			
	K10 below screening		K10 above screening	
Predictors	n	% (95% CI)/M (SE)	n	% (95% CI)/M (SE)
Demographic factors (Time 1)				
Age (mean)	251	33.72 (0.60)	102	32.12 (0.91)
Sex				
Female (ref)	23	76.7 (67.2, 86.2)	7	23.3 (6.1, 40.5)
Male	228	70.6 (60.0, 81.2)	95	29.4 (12.9, 45.9)
Service factors (Time 1)				
Rank				
OFFR (ref)	67	79.8 (71.0, 88.6)	17	20.2 (2.7, 37.7)
NCO	129	72.1 (61.7, 82.5)	50	27.9 (11.3, 44.5)
Other	55	61.1 (48.9, 73.3)	35	38.9 (23.6, 54.2)
Service				
Army	164	68.6 (57.6, 79.6)	75	31.4 (15.2, 47.6)
Navy	14	73.7 (63.6, 83.8)	5	26.3 (9.5, 43.1)
Air Force (ref)	73	76.8 (67.4, 86.2)	22	23.2 (6.0, 40.4)
Length of service (mean)	251	11.98 (0.56)	102	9.95 (0.75)
Deployments experienced at Time 1 (Mean)	251	2.27 (0.16)	102	2.90 (0.32)
Never (ref)	77	75.5 (65.8, 85.2)	25	24.5 (7.5, 41.5)
Ever	174	69.3 (58.4, 80.2)	77	30.7 (14.4, 47.0)
Number of lifetime trauma types (Mean) (Time 1)	251	2.59 (0.15)	102	3.25 (0.26)

5.2.2   Deployment exposures and mental health predictors of elevated psychological distress symptoms

Table 5.2 shows self-reported traumatic and environmental exposures experienced on deployment across a cohort member's military career, as well as problematic anger and mean levels of psychological distress reported pre- and post-deployment (Time 1 and Time 2) according to psychological distress symptom status at Time 3.

The mean number of traumatic exposure types experienced on deployment was higher among those MEAO Deployed Cohort members who had elevated as opposed to low psychological distress symptoms at Time 3 (M = 22.1, SE = 1.3 vs M = 16.6, SE = 0.8; OR 1.04, 95% CI 1.02, 1.06). There was no significant difference in the mean number of environmental exposure types experienced on deployment between those who had elevated compared with low psychological distress symptoms at Time 3 (M = 16.6, SE = 0.6 vs M = 15.5, SE = 0.4).

A categorical breakdown of the number of traumatic and environmental exposure types is also shown in Table 5.2. For both types of exposures the likelihood of having elevated psychological distress symptoms at Time 3 was incrementally greater with increasing numbers of exposure types, although this effect was significant only for traumatic exposures.

Members with and without problematic anger at Time 1 had similar levels of psychological distress at Time 3 (43.8% vs 28.2%), but those with problematic anger at Time 2 were significantly more likely to have elevated distress at Time 3 (59.5% vs 25.3%; OR 2.92, 95% CI 1.36, 6.26). Mean psychological distress symptoms were higher at pre-deployment (Time 1) for those who had elevated as opposed to low psychological distress symptoms at Time 3 (M = 14.3, SE = 0.4 vs M = 12.8, SE = 0.2; OR 1.09, 95% CI 1.03, 1.16). Following the index deployment (Time 2), this difference was larger and again significant (M = 15.8, SE = 0.6 vs M = 13.0, SE = 0.3; OR 1.14, 95% CI 1.08, 1.20).

Table B.11 (in Annex B) shows odds ratios for univariate predictors of psychological distress symptom status at Time 3 in the MEAO Deployed Cohort.

Table 5.2 **Self-reported military career deployment exposures, anger and mean psychological distress in the MEAO Deployed Cohort according to psychological distress symptom status at Time 3**

Predictors	Time 3: Impact of Combat Study			
	K10 below screening		K10 above screening	
	n	% (95% CI)/M (SE)	N	% (95% CI)/M (SE)
Deployment exposures (career) (Time 3)				
Traumatic (mean)	251	16.58 (0.78)	102	22.12 (1.30)
Very low	55	80.9 (72.3, 89.5)	13	19.1 (1.5, 36.7)
Low	58	77.3 (68.0, 86.6)	17	22.7 (5.5, 39.9)
Medium	58	77.3 (68.0, 86.6)	17	22.7 (5.5, 39.9)
High	38	59.4 (46.9, 71.9)	26	40.6 (25.5, 55.7)
Very high	42	59.2 (46.7, 71.7)	29	40.8 (25.7, 55.9)
Environmental (mean)	251	15.49 (0.38)	102	16.59 (0.59)
Low	73	73.7 (63.6, 83.8)	26	26.3 (9.5, 43.1)
Medium	59	76.6 (67.1, 86.1)	18	23.4 (6.2, 40.6)
High	81	71.7 (61.3, 82.1)	32	28.3 (11.7, 44.9)
Very high	38	59.4 (46.9, 71.9)	26	40.6 (25.5, 55.7)
Anger and psychological distress (Time 1 and Time 2)				
Anger (DAR-5) % problematic anger				
Time 1				
No	242	71.8 (61.4, 82.2)	95	28.2 (11.6, 44.8)
Yes	9	56.3 (43.3, 69.3)	7	43.8 (29.1, 58.5)
Time 2				
No	236	74.7 (64.8, 84.6)	80	25.3 (8.4, 42.2)
Yes	15	40.5 (25.4, 55.6)	22	59.5 (47.0, 72.0)
Psychological distress (K10)				
Time 1	251	12.82 (0.24)	102	14.28 (0.40)
Time 2	251	12.98 (0.25)	102	15.83 (0.56)

5.2.3 Multivariate analysis

In order to determine the most important predictors of psychological distress symptom status over time, a multivariate analysis was performed, including all univariate predictors that showed some association with the likelihood of having elevated psychological distress symptom levels at Time 3. The model was adjusted to account for potential differences in levels of symptoms among cohort members who were transitioned as opposed to those who remained in the Regular 2015 ADF at Time 3. The following factors emerged as significant predictors of psychological distress status at Time 3.

The more deployments cohort members had before the index deployment, the greater the likelihood of having elevated psychological distress at Time 3 (OR 1.10, 95% CI 1.00, 1.20). There was also a significant association between the number of traumatic

deployment exposures reported by cohort members during their military career and their likelihood of having elevated psychological distress at Time 3. Those with high or very high exposures were three times more likely to have elevated psychological distress compared with those with very low (high – OR 3.76, 95% CI 1.39, 10.20; very high – OR 3.91, 95% CI 1.41, 10.79) or low exposure (high – OR 2.93, 95% CI 1.19, 7.19; very high – OR 3.04, 95% CI 1.22, 7.57).

Table 5.3   Multivariate predictors of psychological distress symptom status at Time 3 in the MEAO Deployed Cohort

Predictor	Comparison	Adjusted OR (95% CI)	p value
Number of deployments	–	1.10 (1.00–1.20)	0.0461
Traumatic deployment exposures	Low vs very low (ref)	1.29 (0.54–3.06)	ns
	Medium vs very low (ref)	1.89 (0.72–4.97)	ns
	High vs very low (ref)	3.76 (1.39–10.20)	0.0091
	Very high vs very low (ref)	3.91 (1.41–10.79)	0.0086
	Medium vs low (ref)	1.47 (0.61–3.53)	ns
	High vs low (ref)	2.93 (1.19–7.19)	0.019
	Very high vs low (ref)	3.04 (1.22–7.57)	0.0169
	High vs medium (ref)	1.99 (0.90–4.42)	ns
	Very high vs medium (ref)	2.07 (0.94–4.56)	ns
	Very high vs high (ref)	1.04 (0.49–2.19)	ns

ns Not significant.

5.3   Posttraumatic stress

5.3.1   Demographic and Service-related predictors of posttraumatic stress symptoms

Table 5.4 shows the demographic and service characteristics of the MEAO Deployed Cohort at Time 1 according to posttraumatic stress symptom status at Time 3. The mean age of the cohort did not differ between those who had low (M = 33.4, SE = 0.6) as opposed to elevated posttraumatic stress symptoms at Time 3 (M = 33.1, SE = 1.0). A significantly greater proportion of males than females had elevated posttraumatic stress symptoms at Time 3 (25.6% vs 10.3%; OR 4.26, 95% CI 1.14–15.95).

The proportion of MEAO Deployed Cohort members with elevated posttraumatic stress symptoms at Time 3 varied according to rank at Time 1. Other Ranks were more than twice as likely to have elevated posttraumatic stress symptoms compared with Officers (32.9% vs 15.7%; OR 2.56, 95% CI 1.17, 5.59). Non-Commissioned Officers were also more likely than Officers to have elevated posttraumatic stress symptoms at Time 3, although this difference was not significant (24.1 vs 15.7%). The proportion of cohort members with elevated posttraumatic stress symptoms at Time 3 also varied according to Service: Army members were more than twice as likely to report elevated

posttraumatic stress symptoms compared with Air Force members (28.6% vs 15.1%; OR 2.21, 95% CI 1.13, 4.31).

There was no significant difference in length of military service reported at Time 1 between those who had low symptoms of posttraumatic stress and those with elevated levels at Time 3 (M = 11.4, SE = 0.5 vs M = 11.7, SE = 1.0). There was no significant association between the number of previous deployments and the likelihood of elevated posttraumatic stress symptoms at Time 3.

Finally, there was a significant association between the number of lifetime trauma types reported at Time 1 and the likelihood of elevated posttraumatic stress symptoms at Time 3. Those with elevated symptom levels, as opposed to those without, had a greater mean number of lifetime trauma types (M = 3.8, SE = 0.3 vs M = 2.4, SE = 0.1; OR 1.22, 95% CI 1.10, 1.36).

Table 5.4   Demographic and Service characteristics of the MEAO Deployed Cohort at Time 1 according to posttraumatic stress symptom status at Time 3

| | Time 3: Impact of Combat Study | | | |
| | PCL-C below screening | | PCL-C above screening | |
Predictors	n	% (95% CI)/M (SE)	n	% (95% CI)/M (SE)
Demographic factors (Time 1)				
Age (mean)	259	33.36 (0.59)	83	33.14 (1.02)
Sex				
Female (ref)	26	89.7 (83.4, 96.0)	3	10.3 (0.0, 28.9)
Male	233	74.4 (64.5–84.3)	80	25.6 (8.7–42.5)
Service factors (Time 1)				
Rank				
OFFR (ref)	70	84.3 (76.5, 92.1)	13	15.7 (0.0, 33.7)
NCO	132	75.9 (66.3–85.5)	42	24.1 (7.0–41.2)
Other	57	67.1 (55.9, 78.3)	28	32.9 (16.8, 49.0)
Service				
Army	165	71.4 (60.9, 81.9)	66	28.6 (12.0, 45.2)
Navy	15	83.3 (75.3, 91.3)	3	16.7 (0.0, 34.6)
Air Force (ref)	79	84.9 (77.3–92.5)	14	15.1 (0.0–33.2)
Length of service (mean)	259	11.42 (0.53)	83	11.72 (0.98)
Deployments at Time 1 (mean)	259	2.43 (0.17)	83	2.55 (0.29)
Never (ref)	79	81.4 (72.9, 89.9)	18	18.6 (0.9, 36.3)
Ever	180	73.5 (63.4–83.6)	65	26.5 (9.7–43.3)
Number lifetime trauma types (mean) (Time 1)	259	2.44 (0.14)	83	3.81 (0.28)

5.3.2 Deployment exposures and mental health predictors of posttraumatic stress symptoms

Table 5.5 shows self-reported traumatic and environmental exposures experienced during cohort members' military career, as well as problematic anger and mean levels of posttraumatic stress symptoms reported pre- and post-deployment (Time 1 and Time 2) according to posttraumatic stress symptom status at Time 3.

The mean number of traumatic deployment exposures experienced in their career was higher among members who had elevated as opposed to low posttraumatic stress symptoms at Time 3 (M = 24.8, SE = 1.3 vs M = 16.0, SE = 0.8; OR 1.05, 95% CI 1.03, 1.08). Similarly, the mean number of environmental exposure types experienced in their career was higher among those who had elevated as opposed to low posttraumatic stress symptoms at Time 3 (M = 18.0, SE = 0.6 vs M = 15.1, SE = 0.4; OR 1.10, 95% CI 1.04, 1.16). A categorical breakdown of number of traumatic and environmental exposure types is also provided in Table 5.5. This shows that for both types of exposures the likelihood of having elevated posttraumatic stress symptoms at Time 3 was only incrementally greater with increasing numbers of exposure types once a threshold was reached (moderate).

Those with and without problematic anger at Time 1 had similar levels of posttraumatic stress symptoms at Time 3 (26.7% vs 24.2%); in contrast, those with problematic anger at Time 2 were significantly more likely to have elevated posttraumatic stress symptoms at Time 3 (55.6% vs 20.6%; OR 2.67, 95%CI 1.16, 6.18). Posttraumatic stress symptoms at pre-deployment (Time 1) were slightly higher among those who had elevated as opposed to low posttraumatic stress symptoms at Time 3 (M = 22.0, SE = 0.7 vs M = 19.2, SE = 0.2; OR 1.12, 95% CI 1.07, 1.18), while following the index deployment (Time 2) symptoms were substantially higher among those who had elevated as opposed to low posttraumatic stress symptoms (M = 27.0, SE = 1.2 vs M = 20.5, SE = 0.3; OR 1.12, 95% CI 1.08, 1.17).

Table B.12 (in Annex B) shows odds ratios for univariate predictors of posttraumatic stress symptom status at Time 3 in the MEAO Deployed Cohort.

Table 5.5 Self-reported career deployment exposures, anger and mean posttraumatic stress symptoms in the MEAO Deployed Cohort according to posttraumatic stress symptom status at Time 3

		Time 3: Impact of Combat Study		
		PCL-C below screening		PCL-C above screening	
Predictors	n	% (95% CI)/M (SE)	N	% (95% CI)/M (SE)
Deployment exposures (career) (Time 3)				
Traumatic (mean)	259	15.99 (0.77)	83	24.81 (1.32)
Very low (ref)	59	89.4 (83.0–95.8)	7	10.6 (0.0–29.1)
Low	65	89.0 (82.5–95.5)	8	11.0 (0.0–29.5)
Medium	55	75.3 (65.6–85.0)	18	24.7 (7.7–41.7)
High	40	64.5 (52.8–76.2)	22	35.5 (19.8–51.2)
Very high	40	58.8 (46.2–71.4)	28	41.2 (26.2–56.2)
Environmental (mean)	259	15.08 (0.37)	83	17.99 (0.57)
Low (ref)	82	85.4 (77.9, 92.9)	14	14.6 (0.0, 32.7)
Medium	63	84.0 (76.2–91.8)	12	16.0 (0.0–34.0)
High	78	70.9 (60.3, 81.5)	32	29.1 (12.6, 45.6)
Very high	36	59.0 (46.4, 71.6)	25	41.0 (25.9, 56.1)
Anger and posttraumatic stress symptoms (Time 1 and Time 2)				
Anger (DAR-5) % problematic anger				
Time 1				
No	248	75.8 (66.2–85.4)	79	24.2 (7.1–41.3)
Yes	11	73.3 (63.2, 83.4)	4	26.7 (9.9, 43.5)
Time 2				
No	243	79.4 (70.5–88.3)	63	20.6 (3.1–38.1)
Yes	16	44.4 (29.8, 59.0)	20	55.6 (42.5, 68.7)
Posttraumatic stress symptoms (PCL-C)				
Time 1	259	19.15 (0.24)	83	22.02 (0.66)
Time 2	259	20.51 (0.32)	83	26.95 (1.15)

5.3.3 Multivariate analysis

In order to determine the most important predictors of posttraumatic stress symptom status over time, a multivariate analysis was performed, including all univariate predictors that showed some association with the likelihood of having elevated symptom levels at Time 3. The model was adjusted to account for potential differences in levels of symptoms among cohort members who were transitioned as opposed to those who remained in the Regular 2015 ADF at Time 3. The following factors emerged as significant predictors.

The number of lifetime trauma exposure types at Time 1 was a significant predictor of longer term posttraumatic stress symptom status at Time 3 (OR 1.16, 95% CI 1.03, 1.31). There was also a significant association between the number of traumatic deployment exposures reported by cohort members during their military career and

their likelihood of having elevated posttraumatic stress symptoms at Time 3. Compared with members with very low exposure, those with high exposures were three times more likely (OR 3.31, 95% CI 1.00, 10.89); compared with members with low levels of exposure, those with medium exposure were nearly four times more likely (OR 3.87, 95% CI 1.32, 11.34), those with high exposure were nearly five times more likely (OR 4.84, 95% CI 1.60, 14.63), and those with very high exposures were about four times more likely (OR 4.17, 95% CI 1.36, 12.75) to have elevated posttraumatic stress symptoms.

Table 5.6   Multivariate predictors of posttraumatic stress symptom status at Time 3 in the MEAO Deployed Cohort

Predictor	Comparison	Adjusted OR (95% CI)	p value
Number of lifetime trauma types	–	1.16 (1.03–1.31)	0.0179
Traumatic deployment exposures	Low vs Very low (ref)	0.68 (0.21–2.19)	ns
	Medium vs Very low (ref)	2.64 (0.84–8.31)	ns
	High vs Very low (ref)	3.31 (1.00–10.89)	0.0495
	Very high vs Very low (ref)	2.85 (0.84–9.70)	ns
	Medium vs Low (ref)	3.87 (1.32–11.34)	0.0136
	High vs Low (ref)	4.84 (1.60–14.63)	0.0052
	Very high vs Low (ref)	4.17 (1.36–12.75)	0.0123
	High vs Medium (ref)	1.25 (0.55–2.85)	ns
	Very high vs Medium (ref)	1.08 (0.47–2.49)	ns
	Very high vs High (ref)	0.86 (0.38–1.94)	ns

ns Not significant.

5.4   Physical health correlates of long-term mental health

This section presents a descriptive examination of two important physical health outcomes over time according to mental health status at Time 3: the number of self-reported physical health symptoms and biological outcomes limited to inflammatory markers. As with the predictive modelling, results for psychological distress are presented first; they are followed by the results for posttraumatic stress.

5.4.1   Psychological distress

Table 5.7 shows the mean number of self-reported health symptoms over time in the MEAO Deployed Cohort according to psychological distress status at Time 3. The subgroup with elevated psychological distress at Time 3 reported greater numbers of symptoms at all three time points, the difference increasing over time. Interestingly, the mean number of health symptoms reported by the subgroup with low psychological distress remained relatively stable over time

Table 5.7   Mean number of health symptoms reported by MEAO Deployed Cohort across time points by K10 screening cut-off

| | Time 1 (Prospective pre-deployment) n = 422 | | Time 2 (Prospective post-deployment) n = 422 | | Time 3 (Impact of Combat follow-up) | | | | | |
| | | | | | Transitioned ADF n = 130 | | 2015 Regular ADF n = 292 | | Total n = 422 | |
K10 screening cut-off	M	SE	M	SE	M	SE	M	SE	M	SE
Below screening cut-off	7.0	0.4	8.4	0.5	9.4	0.8	9.5	0.5	9.5	0.4
Above screening cut-off	9.5	0.8	14.9	1.0	23.7	1.6	19.1	1.3	20.5	1.0

Note: Total scores for Prospective Study included only those with scores on all variables. Impact of Combat had mean scores imputed for missings.

Table 5.8 shows the levels of key inflammatory markers over time for Combat Zone Subgroup members with low as opposed to elevated psychological distress at Time 3. Both pro-inflammatory and anti-inflammatory markers were lower at Time 1 among those with elevated psychological distress at Time 3. This pattern continued at Time 2. At Time 3 there was some convergence for IL-6 and CRP, but the other markers remained lower. In contrast, cortisol was higher at Time 1 in the elevated psychological distress group, although this difference dissipated at the Time 2 and Time 3 follow-ups.

Table 5.8   Biological outcomes in the MEAO Deployed Cohort across time by Time 3 K10 screening cut-off

| Biological outcome | n | K10 screening cut-off | Time 1 (Prospective pre-deployment) | | Time 2 (Prospective post-deployment) | | Time 3 (Impact of Combat follow-up) | |
			M	SE	M	SE	M	SE
Interleukin 1b	31	Below screening cut-off	0.7	0.4	0.6	0.4	0.3	0.2
	13	Above screening cut-off	0.2	0.2	0.1	0.0	0.0	0.0
Interleukin 6 (IL-6)	32	Below screening cut-off	1340.6	593.6	1489.4	399.7	539.8	196.5
	13	Above screening cut-off	248.3	88.4	757.1	129.2	487.9	97.1
Interleukin 10	32	Below screening cut-off	885.0	359.4	479.0	145.3	402.5	186.1
	13	Above screening cut-off	213.4	70.5	352.2	85.0	211.6	76.1
TNF alpha	32	Below screening cut-off	5623.6	3340.9	7495.5	3235.5	3413.4	1652.0
	13	Above screening cut-off	2371.0	1944.2	2246.3	882.3	1549.9	712.9
C-reactive protein (CRP)	38	Below screening cut-off	0.9	0.3	1.8	0.7	1.2	0.3
	16	Above screening cut-off	0.3	0.2	1.3	0.5	2.0	0.7
Cortisol	32	Below screening cut-off	12849.9	1534.6	13406.2	1433.6	10443.7	1448.4
	14	Above screening cut-off	15893.3	1979.9	12150.8	1575.7	10380.8	1838.0

5.4.2   Posttraumatic stress symptoms

Table 5.9 presents mean self-reported physical health symptoms over time in MEAO Deployed Cohort members with low as opposed to elevated posttraumatic stress symptoms at Time 3. Among those with low posttraumatic stress symptoms, the overall number of physical health symptoms was lower and remained relatively stable

over time. Physical health symptoms were higher among those with elevated posttraumatic stress symptoms at all three time points, this difference increasing across time.

Table 5.9   Mean number of health symptoms reported by MEAO Deployed Cohort across time points by PCL screening cut-off

| | Time 1 (Prospective pre-deployment) n = 421 | | Time 2 (Prospective post-deployment) n = 421 | | Time 3 (Impact of Combat 5-year follow-up) | | | | | |
| | | | | | Transitioned ADF n = 117 | | 2015 Regular ADF n = 304 | | Total n = 421 | |
PCL screening cut-off	M	SE	M	SE	M	SE	M	SE	M	SE
Below screening cut-off	6.7	0.4	8.0	0.4	10.3	1.0	9.1	0.5	9.3	0.4
Above screening cut-off	10.5	0.9	16.6	1.1	23.4	1.6	21.8	1.3	22.4	1.0

Note: Total scores for Prospective Study included only those with scores on all variables. Impact of Combat had mean scores imputed for missings.

Table 5.10 presents levels of key inflammatory markers over time among Combat Zone Subgroup members with low as opposed to elevated posttraumatic stress symptoms at Time 3. All pro-inflammatory markers with the exception of CRP (IL-1b, IL-6, TNF) were lower in those with elevated posttraumatic stress symptoms at Time 3. Interestingly, levels of the anti-inflammatory marker IL-10 were higher in this subgroup, as was the case with cortisol. The difference in cortisol levels, and to a lesser extent IL-6 levels, dissipated with time.

Table 5.10   Biological outcomes in the Combat Zone subgroup across time by Time 3 PCL screening cut-off

| Biological outcomes | N | PCL screening cut-off | Time 1 (Prospective pre-deployment) | | Time 2 (Prospective post-deployment) | | Time 3 (Impact of Combat 5-year follow-up) | |
			M	SE	M	SE	M	SE
Interleukin 1b (IL-1b)	29	Below screening cut-off	808.2	433.0	572.5	368.3	339.4	227.6
	13	Above screening cut-off	76.7	60.8	216.2	180.3	56.7	36.3
Interleukin 6 (IL-6)	30	Below screening cut-off	1236.5	631.9	1313.9	406.9	585.9	208.3
	13	Above screening cut-off	641.3	256.0	1244.7	372.7	440.5	99.7
Interleukin 10 (IL-10)	30	Below screening cut-off	610.6	257.3	387.7	113.9	249.6	59.9
	13	Above screening cut-off	950.4	688.1	612.0	256.9	626.1	445.2
TNF alpha (TNF)	30	Below screening cut-off	6419.3	3618.8	7462.9	3432.2	3800.1	1751.4
	13	Above screening cut-off	626.2	318.2	2226.6	943.4	1156.8	676.4
C-reactive protein (CRP)	34	Below screening cut-off	0.8	0.3	1.8	0.7	1.4	0.4
	17	Above screening cut-off	0.8	0.4	1.7	0.5	1.9	0.4
Cortisol	30	Below screening cut-off	12566.9	1613.2	12185.8	1230.1	10236.0	1474.6
	14	Above screening cut-off	16990.5	1884.4	14940.0	2413.9	10133.5	1903.6

6   Neurocognitive function in the Combat Role High-risk Subgroup

Neurocognitive function over time

The overall pattern of findings for the Combat Role High-risk Subgroup suggests that deployment and combat exposure might have lasting impacts on resting brain state and attentional and memory processes.

Quantitative electroencephalography

- Beta power and alpha power showed reductions from Time 1 to Time 2 that were sustained at Time 3. This is indicative of reduced cognitive engagement and reduced relaxed wakefulness. In contrast, theta and delta power increased from Time 1 to Time 2 and elevations were sustained at Time 3, suggesting an increase in memory processing.

  - Beta power reduced by 20.1% from Time 1 to Time 2. Reductions were most robustly observed in the occipital, parietal and bilateral temporal regions. Although some recovery was observed at Time 3, this was incomplete and sustained reductions remaining across the majority of regions.

  - Alpha power reduced by 10.5% from Time 1 to Time 2. Reductions were most robustly observed in the occipital, left temporal and frontal regions. Although some recovery was observed at Time 3, this was incomplete and sustained reductions persisted, most notably in the frontal and occipital regions.

  - Theta power increased by 3.6% from Time 1 to Time 2. Increases were most robustly observed in the central and right temporal regions. At Time 3 global average theta power was shown to have increased further, and sustained elevations were observed in the central, parietal and temporal regions.

  - Delta power increased by 10.6% from Time 1 to Time 2. Increases were most robustly observed in the temporal, frontal, central and parietal regions. At Time 3 the majority of electrodes showed substantial recovery towards Time 1 levels. Sustained elevations were, however, observed at more anterior bilateral temporal electrodes.

Working memory

- Reductions in P3wm amplitudes were observed over time, with successive reductions from Time 1 to Time 2 then to Time 3. These reductions were most notable at frontal and central electrodes. This component provides an objective measure of working memory functioning, and its amplitude is a measure of the efficiency of processing, whereby greater amplitude reflects greater efficiency. Thus the observed reductions are consistent with reduced efficiency of memory processes.

Neurocognitive function and elevated psychological distress and posttraumatic stress symptoms

Deployment appears to have an acutely altering effect on functioning in attentional orientation networks. The findings showed the following:

- Functional decrements in attentional networks were evident among ADF members with low psychological symptoms at Time 3 and those with elevated posttraumatic stress symptoms.

- Attentional hypervigilance was evident among members with elevated psychological distress symptoms at Time 3.

- Acute deployment-related effects appear to resolve in those with low symptoms or elevated psychological distress symptoms at Time 3.

- Acquired functional decrements appear to be progressively exacerbated in those with elevated posttraumatic stress. Executive memory network impairments also became evident over the long term.

Quantitative electroencephalography

- Together, the findings suggest that individuals who manifest psychological symptoms over time exhibit a range of distinct qEEG characteristics, with beta and theta power bands bearing the closest association with current psychological symptom status at Time 3. It appears that higher beta and theta power levels at Time 1 might potentially be vulnerability markers for the emergence of future psychological symptoms.

- For members with elevated psychological distress the findings showed the following:

  – The reduction in beta power between Time 1 and Time 2 was less pronounced compared with those with low psychological symptoms.

  – The increase in beta power between Time 2 and Time 3 was more pronounced compared with those with low psychological symptoms.

  – These members exhibited progressive alpha power decrements at all three time points.

  – They had lower global alpha power at Time 1 when compared with those with low psychological symptoms, and they had progressive reductions in alpha power over time.

  – They recorded theta power reductions between Time 1 and Time 2 and robust increases were observed between Time 2 and Time 3, whereas among those with low psychological symptoms theta power stayed relatively stable at all three time points.

- For members with elevated posttraumatic stress symptoms the findings showed the following:

  – Beta power levels were higher at all three time points compared with those with low psychological symptoms.

- These members exhibited beta power reductions between Time 1 and Time 2 and an increase between Time 2 and Time 3.

- They showed contrasting patterns of change in alpha power between Time 1 and Time 2 and Time 2 and Time 3.

- They showed progressive decreases in alpha power over time.

- They showed reduction trends in theta power between Time 1 and Time 2 compared with those with low psychological symptoms, who remained stable.

- They showed robust theta power increases over time, in contrast with marginal theta power reductions between Time 2 and Time 3 for members with low psychological symptoms.

Working memory

- ERP (event-related potential) indices can serve as a marker of emerging subsyndromal distress in this population, the findings being indicative of acutely acquired (that is, deployment-related) attentional network impairments followed by progressive exacerbation of these in the longer term. While deployment appears to predominantly affect anterior attentional network functions, there can with time be progressive impacts on posterior executive memory network functions. The findings also provide evidence that fronto-central amplitude reductions may pre-exist PTSD symptom onset, although these deficits may reflect higher cumulative trauma exposure and early signs of symptom development.

- Specifically:

  - For members with elevated psychological distress the findings showed that P3wm amplitudes were minimal at the frontal electrode and maximal at the parietal electrode at all time points. In those with low psychological symptoms a contrasting pattern was observed.

- For those with elevated posttraumatic stress symptoms:

  - They exhibited frontal amplitude reductions between Time 1 and Time 2.

  - P3wm amplitudes were minimal at the frontal electrode and maximal at the parietal electrode at all time points.

  - They exhibited somewhat less pronounced frontal amplitude reductions between Time 1 and Time 2 and markedly more pronounced frontal amplitude reductions between Time 2 and Time 3 when compared with those with low psychological symptoms.

  - They exhibited less-pronounced central amplitude reductions between Time 1 and Time 2 and somewhat more pronounced central amplitude reductions between Time 2 and Time 3 when compared with those with low psychological symptoms.

  - They exhibited lower parietal amplitudes at Time 1, comparable amplitudes at Time 2 and relatively lower amplitudes at Time 3 when compared with those with low psychological symptoms.

This chapter focuses on neurocognitive functioning in the Combat Role High-risk Subgroup of the MEAO Deployed Cohort. Resting brain activity as measured by qEEG is examined, along with working memory activity. The shifts in measures of resting cortical activity and working memory function over time are first described. This is followed by a discussion of these indices in relation to mental health outcomes. The chapter overviews trends in resting-state qEEG power levels and working memory function change over time in the full sample (all participants who completed neurocognitive assessments at all three time points, regardless of missing data on other measures). Following this is an examination of the trajectory of neurocognitive function over time among those with elevated psychological distress or elevated posttraumatic stress at Time 3.

6.1 Demographic characteristics of neurocognitive testing responders at Time 3 (Impact of Combat Study)

A total of 51 Combat Role High-risk Subgroup members (10 Transitioned ADF members and 41 2015 Regular ADF members) had full neurocognitive data available (Times 1, 2 and 3) and were included in analyses for this chapter. Their demographic profile was as follows.

The mean age of the responders was 33.4 years (SE = 1.1). Most were 28–37 years old (52.9%); 23.5% were 18–27 years old, 15.7% were 38–47 years old, and 7.8% were 48–57 years old. No responders were 58 years or older. All the responders were Army, and most were male (92.2%). Non-Commissioned Officers made up 58.8% of the responders; 29.4% were from Other Ranks and 7.8% were Officers (3.9% had missing demographic data).

6.2 Neurocognitive function over time

This section summarises resting-state qEEG power levels and working memory function trends over time in the full Combat Role High-risk Subgroup (all participants who completed neurocognitive assessments at all three time points, regardless of missing data on other measures). A summary of changes in resting cortical activity and working memory function observed between Time 1, Time 2 and Time 3 is presented. Because of the limited sample size, results were not stratified according to whether cohort members had transitioned or remained in the Regular ADF in 2015.

6.2.1 Quantitative electroencephalography

This section discusses the change over time in qEEG measures of resting-state cortical activity. Four basic rhythms, each associated with particular physiological and functional states, are examined in order of their frequency and amplitude – beta, alpha, theta and delta. Each rhythm varies according to its frequency and amplitude;

'frequency' refers to how often the signal occurs (fast to slow) and 'amplitude' refers to the signal's strength (low to high). In simple terms, beta rhythms are high frequency and low amplitude and are present during active cognitive engagement; alpha rhythms are slightly lower frequency and higher amplitude, are present during relaxed wakefulness, and are thus reflective of a resting idle state; theta rhythms are slower again, of a higher amplitude, and associated with memory processes, also appearing during deep meditation and hypnosis; delta rhythms are the slowest, have the greatest amplitude, and are most prominently associated with sleep and dreaming states.

Beta power

Table 6.1 and Figure 6.1 show beta power changes over time in the Combat Role High-risk Subgroup. There was a general pattern suggesting reduced active cognitive processing, with reductions in beta power over time. Beta power reduced between Time 1 and Time 2 for the majority of electrodes, with a global power reduction of 20.1%. Reductions were most robustly observed in the occipital, parietal and bilateral temporal regions, although substantial reductions were also observed in the frontal and central regions. At Time 3 the majority of electrodes exhibited some recovery towards Time 1 power levels, although sustained reductions remained apparent across the majority of regions (12.3% global average power reductions relative to Time 1). These sustained reductions were again most robustly observed in the occipital, parietal and bilateral temporal regions, although substantial sustained reductions also remained evident in the left-frontal and central regions.

Table 6.1   Regional average percentage change in beta power relative to Time 1

Region	Percentage change relative to Time 1	
	Time 2	Time 3
Global	−20.1%	−12.3%
Frontal	−13.6% [left −16.8%; right −10.5%]	−3.1% [left −8.0%; right −2.2%]
Central	−13.1%	−5.8%
Parietal	−21.2%	−12.8%
Temporal	−24.0% [left −28.2%; right −19.8%]	−22.1% [left −24.7%; right −19.5%]
Occipital	−35.8%	−26.5%

Note: Global = all electrodes; frontal = Fp1/Fp2/F7/F3/Fz/F4/F8 [left = Fp1/F7/F3; right = Fp2/F8/F4]; central = C3/Cz/C4; parietal = P3/Pz/P4; temporal = T3/T4/T5/T6 [left = T3/T5; right = T4/T6]; occipital = O1/Oz/O2.

Figure 6.1   Mean beta power (top) and percentage change over time (bottom)
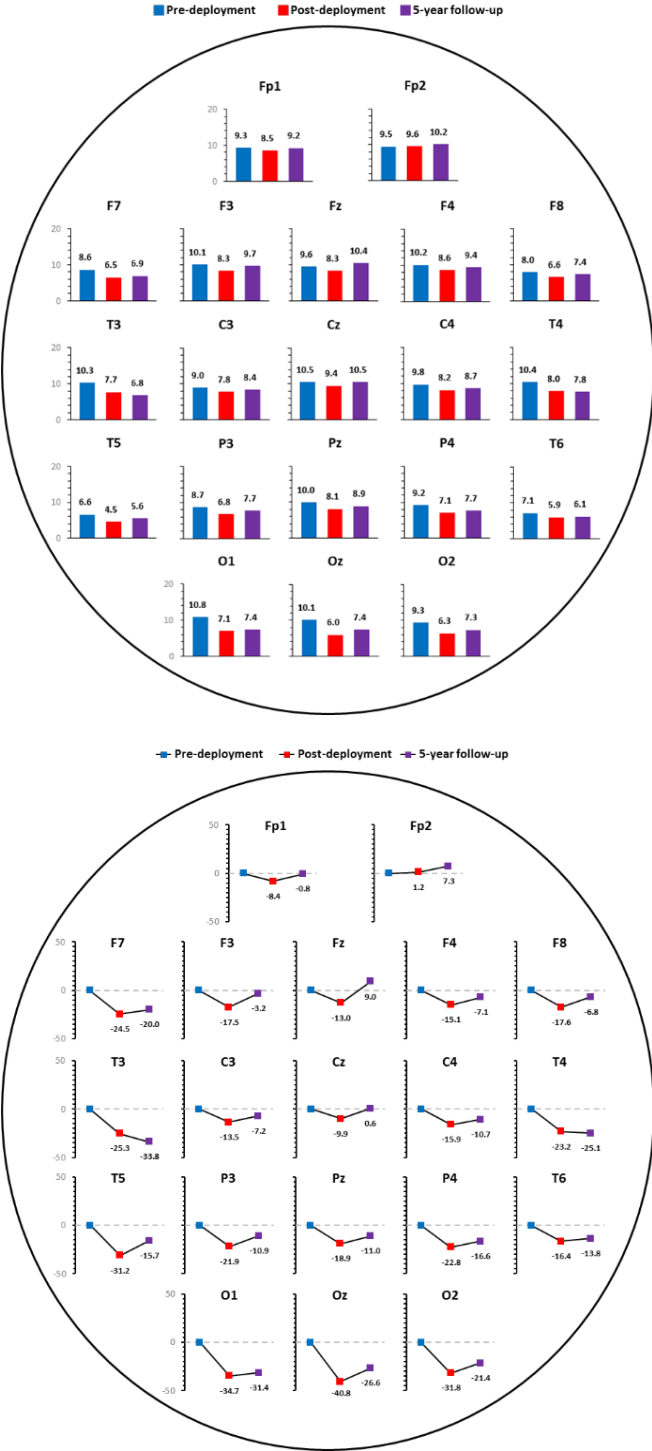
Alpha power

Table 6.2 and Figure 6.2 show alpha power changes over time in the Combat Role High-risk Subgroup. Alpha power reduced for the vast majority of electrodes over time, with a global average reduction of 10.5% between Time 1 and Time 2. Reductions were shown to be most robust in the occipital, left-temporal and frontal regions, although notable power reductions were also observed in the central and parietal regions.

At Time 3 the majority of electrodes exhibited some recovery towards Time 1 power levels, although sustained reductions remained apparent in several regions (7.0% global average power reductions relative to Time 1). These sustained reductions were most robustly observed in the frontal regions, but notable sustained reductions also remained evident at occipital electrodes. The bilateral-temporal regions exhibited mixed trends, although regional averages appeared to show near complete recovery to Time 1 power levels. Central electrodes also exhibited a trend towards recovery to Time 1 power levels. Most interestingly, parietal electrodes were shown to exhibit substantial additional alpha power reductions from those observed at Time 2. These additional parietal power reductions resulted in a robust downward trend over time at this location.

Table 6.2   Regional average percentage change in alpha power relative to Time 1

Region	Percentage change relative to Time 1	
	Time 2	Time 3
Global	−10.5%	−7.0%
Frontal	−12.3% [left −13.5%; right −12.2%]	−8.6% [left −11.2%; right −6.5%]
Central	−6.2%	−1.8%
Parietal	−6.7%	−17.7%
Temporal	−9.3% [left −15.6%; right −3.0%]	−0.8% [left −1.6%; right 0.1%]
Occipital	−16.3%	−5.9%

Note: Global = all electrodes; frontal = Fp1/Fp2/F7/F3/Fz/F4/F8 [left = Fp1/F7/F3; right = Fp2/F8/F4]; central = C3/Cz/C4; parietal = P3/Pz/P4; temporal = T3/T4/T5/T6 [left = T3/T5; right = T4/T6]; occipital = O1/Oz/O2.

Figure 6.2   Mean alpha power (top) and percentage change over time (bottom)
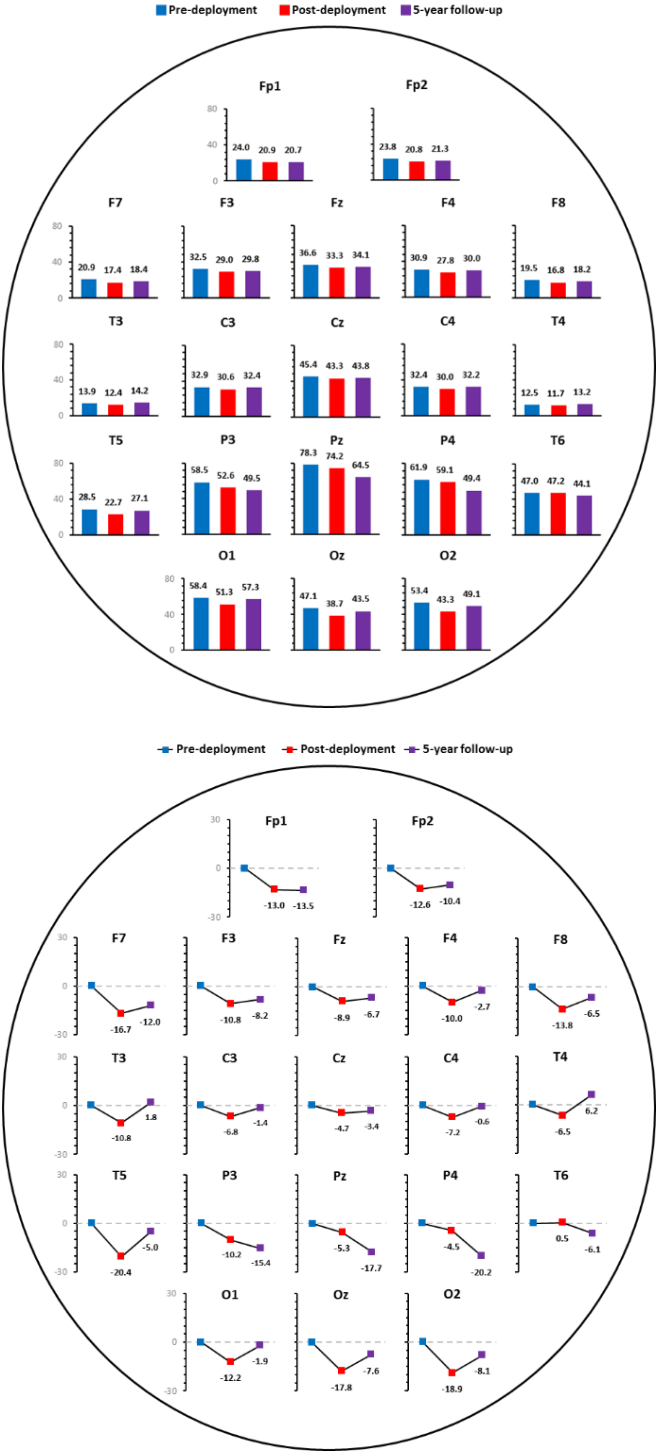
Theta power

Table 6.3 and Figure 6.3 show theta power change over time in the Combat Role High-risk Subgroup. Theta power showed a trend to increase over time for the majority of electrodes, exhibiting a global average power increase of 3.6% from Time 1 to Time 2. These increases were shown to be most robust in the central and right temporal regions, although notable increases were also observed in the frontal and parietal regions. In contrast with other regions, occipital theta reduced between Time 1 and Time 2.

At Time 3 global average theta power increased further, with an average increase of 4.9% between Time 1 and Time 3. Notably, some recovery towards Time 1 power levels was observed at several electrodes (Fz/Cz/Pz/P4), although sustained increases were evident in a number of locations. Sustained or additional theta power increases at Time 3 were observed in the central, parietal and temporal regions. Additional power increases were most robustly observed at more anterior bilateral temporal electrodes (T3/T4). Interestingly, in contrast with reductions observed at Time 2, at Time 3 occipital theta exhibited a robust power increase that exceeded levels observed at Time 1.

Table 6.3   Regional average percentage change in theta power relative to Time 1

Region	Percentage change relative to Time 1	
	Time 2	Time 3
Global	3.6%	4.9%
Frontal	4.2% [left 4.7%; right 2.8%]	1.9% [left 2.3%; right 2.2%]
Central	9.3%	8.5%
Parietal	5.4%	4.8%
Temporal	5.3% [left 3.4%; right 7.1%]	7.0% [left 7.0%; right 6.9%]
Occipital	–7.8%	5.8%

Note: Global = all electrodes; frontal = Fp1/Fp2/F7/F3/Fz/F4/F8 [left = Fp1/F7/F3; right = Fp2/F8/F4]; central = C3/Cz/C4; parietal = P3/Pz/P4; temporal = T3/T4/T5/T6 [left = T3/T5; right = T4/T6]; occipital = O1/Oz/O2.

Figure 6.3   Mean theta power (top) and percentage change over time (bottom)
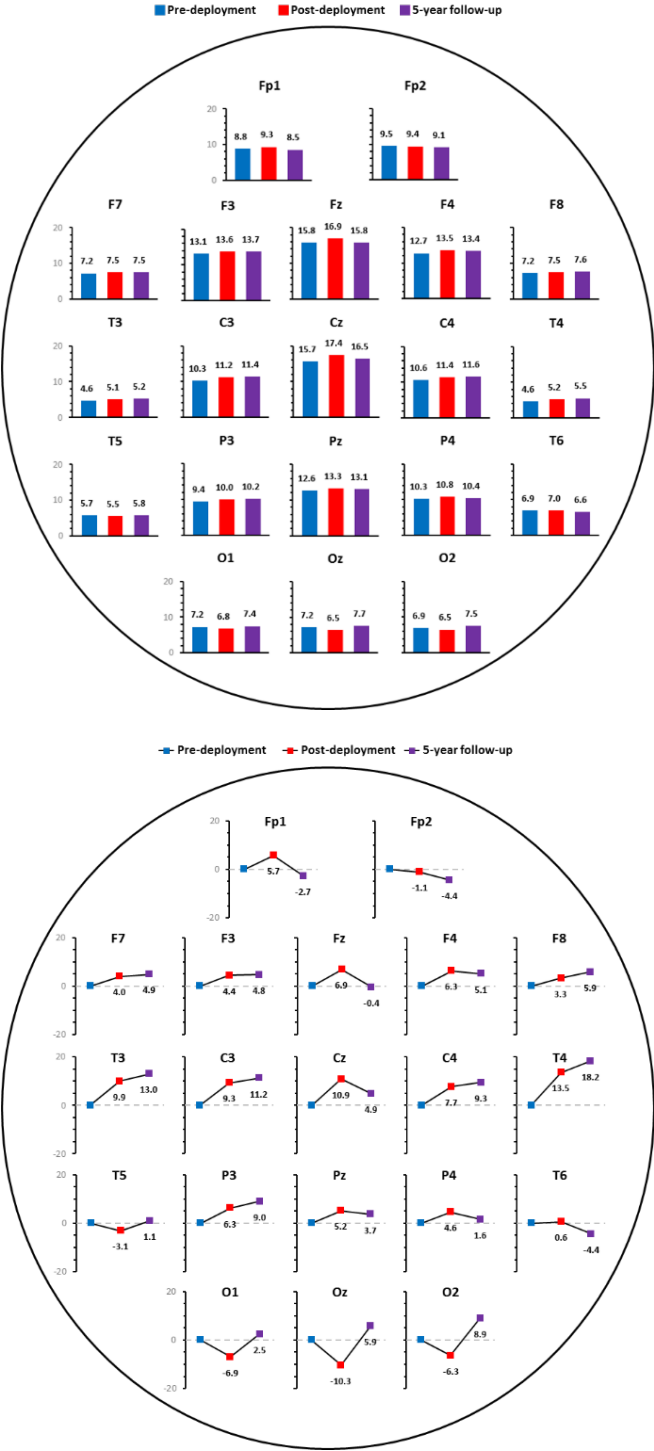
Delta power

Table 6.4 and Figure 6.4 show delta power change over time in the Combat Role High-risk Subgroup. Delta power increased over time for the majority of electrodes, with a global average power increase of 10.6% between Time 1 and Time 2. These increases were shown to be most robust in the temporal, frontal, central and parietal (Pz/P4) regions. Occipital delta exhibited little change bilaterally, although a modest midline (Oz) power reduction was observed.

At Time 3 the majority of electrodes exhibited a substantial recovery towards Time 1 power levels, although global average power was still 2.5% higher relative to Time 1. Sustained power increases in particular remained evident at more anterior bilateral temporal electrodes (T3/T4). Notably, occipital delta exhibited successive power increases at each time point, particularly in the right hemisphere (O2).

Table 6.4   Regional average percentage change in delta power relative to Time 1

Region	Percentage change relative to Time 1	
	Time 2	Time 3
Global	10.6%	2.5%
Frontal	10.7% [left 14.3%; right 7.0%]	1.0% [left 2.2%; right –1.2%]
Central	9.9%	1.0%
Parietal	6.0%	–0.7%
Temporal	23.6% [left 22.4%; right 24.8%]	6.5% [left 6.7%; right 6.2%]
Occipital	–1.7%	5.4%

Note: Global = all electrodes; frontal = Fp1/Fp2/F7/F3/Fz/F4/F8 left = Fp1/F7/F3; right = Fp2/F8/F4]; central = C3/Cz/C4; parietal = P3/Pz/P4; temporal = T3/T4/T5/T6 [left = T3/T5; right = T4/T6]; occipital = O1/Oz/O2.

Figure 6.4   Mean delta power (top) and percentage change over time (bottom)
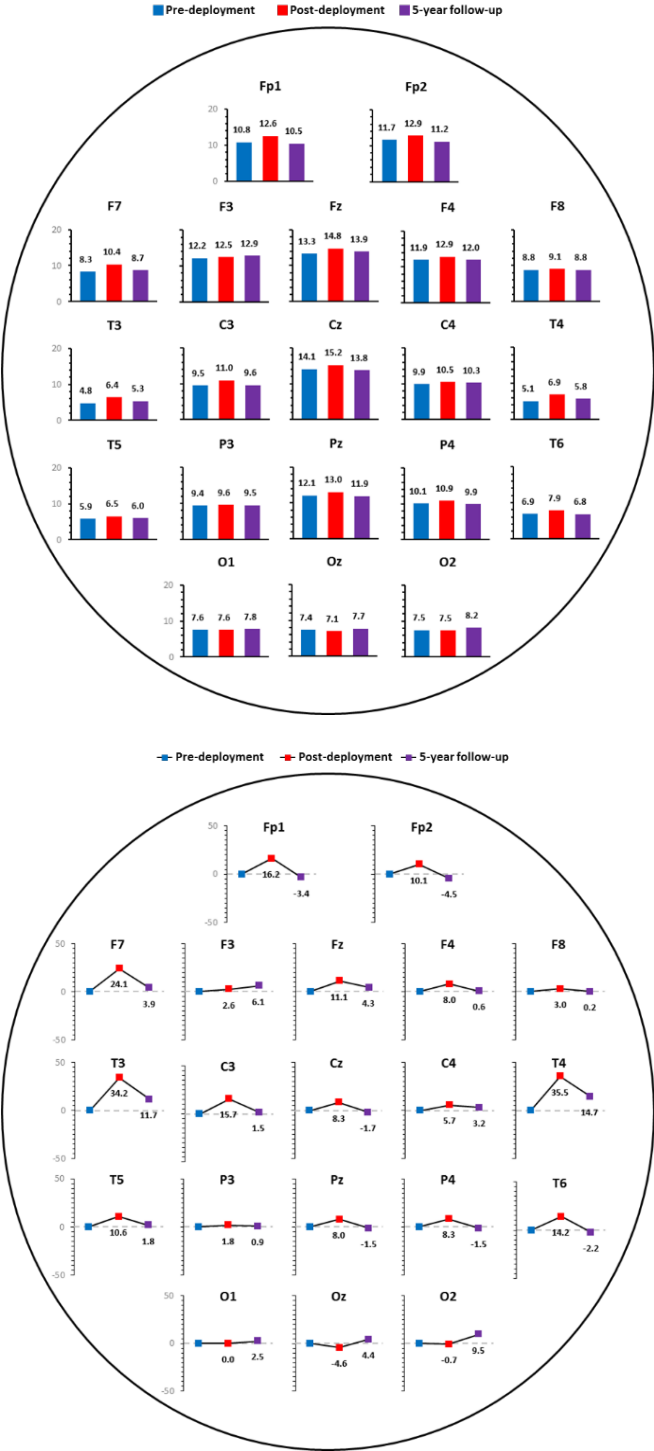
6.2.2 Working memory: event-related potential

This section summarises changes over time in working memory function, as measured by P3wm amplitudes, among the Combat Role High-risk Subgroup. The P3 component is a later latency positive-going amplitude deflection that typically peaks 250 to 500 milliseconds post-stimulus. In general terms, later components (greater than 200 milliseconds) such as the P3 reflect conscious processing events, which are associated with increasingly higher order cognitive functions (that is, effortful information retention, evaluation and manipulation). P3 amplitude deflections elicited during a stimulus task are used as an index of cognitive processing events associated with working memory updating. The P3 amplitude deflection elicited during working memory updating tasks is commonly referred to as the 'P3wm component'. Amplitudes are measured at three electrode locations – frontal, central and parietal.

P3wm peak amplitudes

Figure 6.5 shows mean P3wm amplitudes and changes in amplitudes over time. P3wm amplitudes were maximal at parietal and minimal at frontal electrodes for all three assessment intervals.

P3wm amplitudes reduced over time for all three electrodes. Between Time 1 and Time 2 these reductions were most robustly observed at the frontal and central electrodes; in contrast, the parietal electrode exhibited very little reduction. At Time 3 the frontal and central electrodes exhibited further amplitude reductions; in contrast, the parietal electrode exhibited no amplitude reduction beyond that observed between Time 1 and Time 2.

Figure 6.5 **Midline P3wm amplitude means (top) and percentage change over time (bottom) for frontal (Fz), central (Cz) and parietal (pz) electrodes**
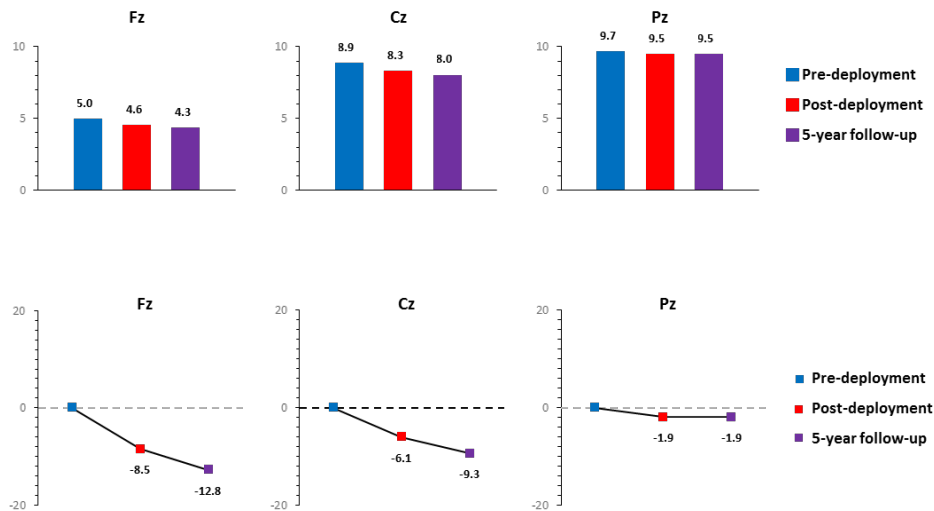
6.3 Neurocognitive function and psychological distress

This section provides an overview of trends in resting-state qEEG power levels and working memory function trends over time among cohort members with elevated psychological distress at Time 3 (scoring above the K10 screening cut-off), as well as comparing them with a healthy subgroup (those scoring below K10 and PCL-C screening cut-offs at Time 3). For the purpose of these analyses, only beta, alpha and theta power levels are included under qEEG.

6.3.1 qEEG

Beta power

At Time 3, when the full Combat Role High-risk Subgroup was divided according to the presence or absence of elevated psychological distress (an indicator of psychopathology), a difference in the pattern of change in beta power over time emerged. At Time 1 those with elevated psychological distress exhibited beta power 12.2% higher than the healthy subgroup. These between-group differences became more pronounced at Time 2 (13.9% higher) and markedly more pronounced at Time 3 (33.4% higher). This progressively increasing beta power disparity was a result of somewhat contrasting change trends in each of the groups. Specifically, while there was a reduction in beta power between Time 1 and Time 2 for both groups, the reduction was more pronounced in the healthy subgroup. Similarly, while both groups exhibited power increases between Time 2 and Time 3, there were more marked

increases in beta power in those with elevated psychological distress compared to the healthy subgroup. This resulted in markedly different beta power levels between the groups at Time 3.

For those with elevated psychological distress there was an average beta power reduction of 13.9% between Time 1 and Time 2. Although beta power reductions were evident for most sites (particularly at more posterior regions), increases were observed at Fp1/Fp2 electrodes.

Global average beta power increased by 29.3% between Time 2 and Time 3 among those with elevated psychological distress, with increases particularly at occipital and anterior temporal electrodes [T3/T4], although power levels at Fp1/Fp2 notably remained stable. Power increases resulted in overall elevated power levels relative to Time 1 at all other electrodes (particularly in the right hemisphere/anterior regions).

Table 6.5   Regional mean beta power levels over time in the elevated psychological distress subgroup

Region	Time 1	Time 2	Time 3
Global	8.7	7.5	9.5
Left hem	8.5	7.1	8.9
Right hem	8.6	7.7	9.6
Asym [L–R]	-0.1	-0.6	-0.7
Anterior	9	8.2	9.9
Posterior	8.1	6.2	8.4
AntPos [A–P]	0.9	2.1	1.5
Frontal	8.6	8.5	10.2
Left hem	8.5	8.1	9.4
Right hem	8.5	9	10.5
Asym [L–R]	0	-1	-1.1
Central	9.5	8.6	11.4
Parietal	8.4	7.3	9.8
Temporal	8.3	6.1	7.9
Left	7.9	5.7	7.5
Right	8.7	6.5	8.3
Asym [L–R]	-0.8	-0.8	-0.8
Occipital	9.2	5.9	7.8

Table 6.6   Regional mean beta power levels over time in the healthy subgroup

Region	Time 1	Time 2	Time 3
Global	7.8	6.5	7.2
Left hem	7.6	6.4	6.8
Right hem	7.7	6.4	7.1
Asym [L–R]	-0.1	0	-0.3
Anterior	8.1	6.9	7.8
Posterior	7.4	5.7	6.3
AntPos [A–P]	0.6	1.2	1.5
Frontal	7.9	6.9	8.3
Left hem	7.9	6.8	8
Right hem	7.8	6.8	8.1
Asym [L–R]	0.1	0	-0.1
Central	7.9	7.5	7.9
Parietal	7.9	6.5	7
Temporal	7	5.8	5.6
Left	7	6	5.1
Right	7.1	5.6	6
Asym [L–R]	-0.1	0.4	-0.9
Occipital	8.1	5.8	6.5

Figure 6.6   **Mean beta power over time in the elevated psychological distress subgroup compared with the healthy subgroup**
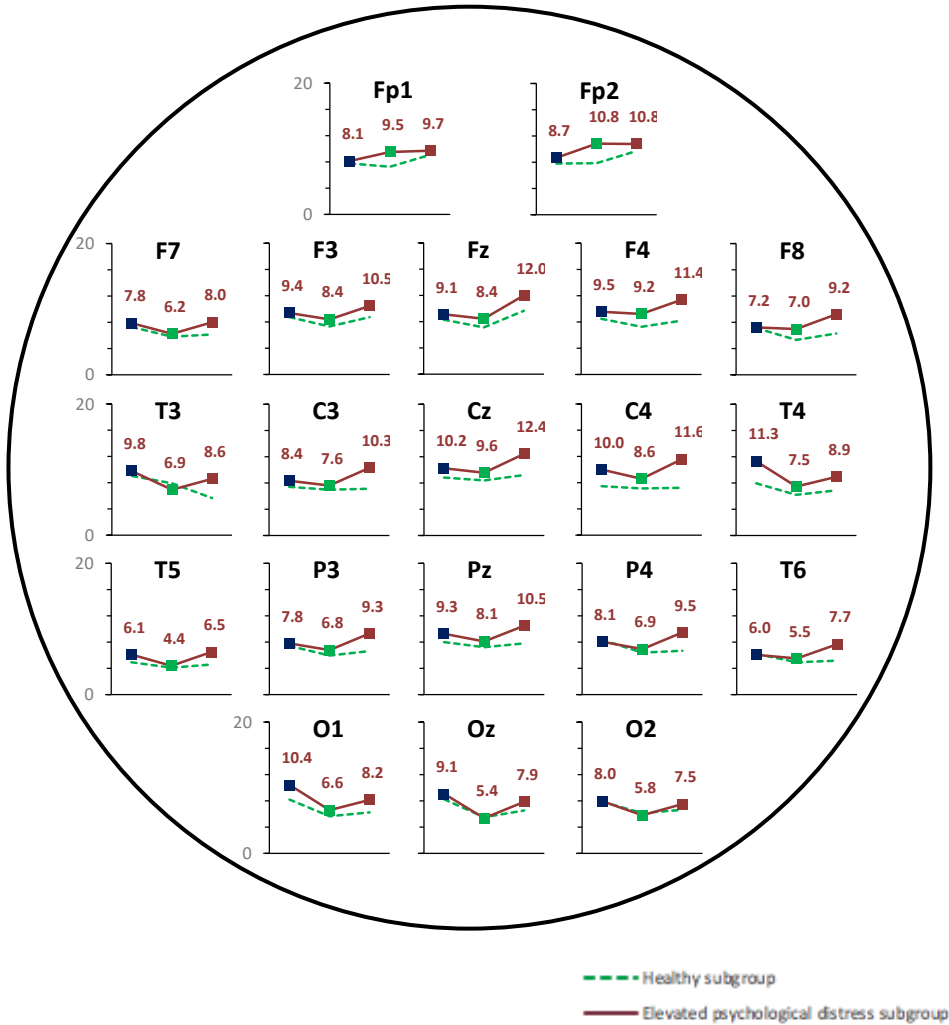
Alpha power

Cohort members with elevated psychological distress exhibited progressive alpha power decrements at all three time points. A global average alpha power reduction of 5.7% was observed between Time 1 and Time 2. Notably, despite this global reduction, alpha power increases were evident at the C3/Cz and P3/P4 electrodes, while relatively stable power levels were evident at the T3/T6, C4 and Pz electrodes. Reduction trends were observed at all other electrodes (particularly across the occipital region). A further global alpha power reduction of 2.5% was evident between Time 2 and Time 3 for those with elevated psychological distress. Despite this overall reduction, power increases between Time 2 and Time 3 were observed at the occipital, left temporal, T4 and C4 electrodes. Power increases resulted in near complete recovery to Time 1 power levels at the T4/T5 electrodes. Increases also resulted in partial recovery to Time 1 power levels across the occipital regions.

Stable power levels between Time 2 and Time 3 were observed at F7/F4/F8. Reductions from Time 2 levels were evident across all other electrodes. Interestingly, power reductions at C3/Cz and P3 contrasted with the increases observed at these sites between Time 1 and Time 2. Power reductions were also observed at Pz/P4 and T6. Further reductions between Time 2 and Time 3 at frontal pole and F3/Fz electrodes resulted in progressive power decrements over time. Overall reduction trends across the three time points were somewhat more pronounced in the right hemisphere and in more posterior regions.

The pattern of change in alpha power over time in the healthy subgroup was slightly different from that for members with elevated psychological distress. The healthy subgroup had higher global alpha power at Time 1 when compared with those with elevated psychological distress, yet they also exhibited a reduction of 13.9% between Time 1 and Time 2. Reduction trends for the healthy subgroup were evident at all electrodes (particularly in more anterior regions). In contrast to the progressive reductions observed for those with elevated psychological distress, global alpha power remained relatively stable between Time 2 and Time 3 in the healthy subgroup, with an average reduction of just 0.7%. Although overall power levels remained stable between Time 2 and Time 3, regional power changes revealed mixed trends. Progressive power decrements were evident at parietal, Fp1, Cz and T6 electrodes. Stable trends were observed at Fp2/F7/F3/Fz and C3/C4 electrodes. Increases were evident at all other electrodes. T4 and O1 electrodes exhibited near complete recovery to Time 1 power levels. Sustained reductions remained evident at remaining electrodes (left temporal, Oz/O2 and F4/F8).

Table 6.7   Regional mean alpha power levels for the elevated psychological distress subgroup

Region	Time 1	Time 2	Time 3
Global	32.2	30.6	28.8
Left hem	27.9	26.9	26.2
Right hem	30.5	28.4	26.6
Asym [L–R]	-2.5	-1.6	-0.4
Anterior	21.6	19.7	19.5
Posterior	44.8	42.1	38.4
AntPos [A–P]	-23.2	-22.4	-18.9
Frontal	24.5	22.2	21.5
Left hem	23.3	20.8	19.8
Right hem	22.6	20.6	20.4
Asym [L–R]	0.7	0.1	-0.5
Central	30.5	32.4	31.4
Parietal	52.5	55.6	45.2
Temporal	21.5	20.3	19
Left	17.1	15.5	17.3
Right	25.9	25.1	20.8
Asym [L–R]	-8.9	-9.6	-3.5
Occipital	45.9	37	39.9

Table 6.8   Regional mean alpha power levels over time in the healthy subgroup

Region	Time 1	Time 2	Time 3
Global	40.8	35.5	34.2
Left hem	36.5	31.2	30.9
Right hem	38.2	33	31.7
Asym [L–R]	-1.7	-1.8	-0.8
Anterior	25.6	21.3	21.7
Posterior	59	52.2	48.5
AntPos [A–P]	-33.4	-30.9	-26.8
Frontal	29.1	24	24.3
Left hem	28	23	22.7
Right hem	26.6	21.7	22.7
Asym [L–R]	1.5	1.3	0
Central	38.4	34.1	33.3
Parietal	76.5	66.4	53.7
Temporal	27.5	24.9	24.8
Left	22.8	19.4	20.7
Right	32.2	30.5	29
Asym [L–R]	-9.4	-11.1	-8.3
Occipital	52.9	47.3	50.9

Figure 6.7

Figure 6.7   Mean alpha power over time in the elevated psychological distress subgroup compared with the healthy subgroup
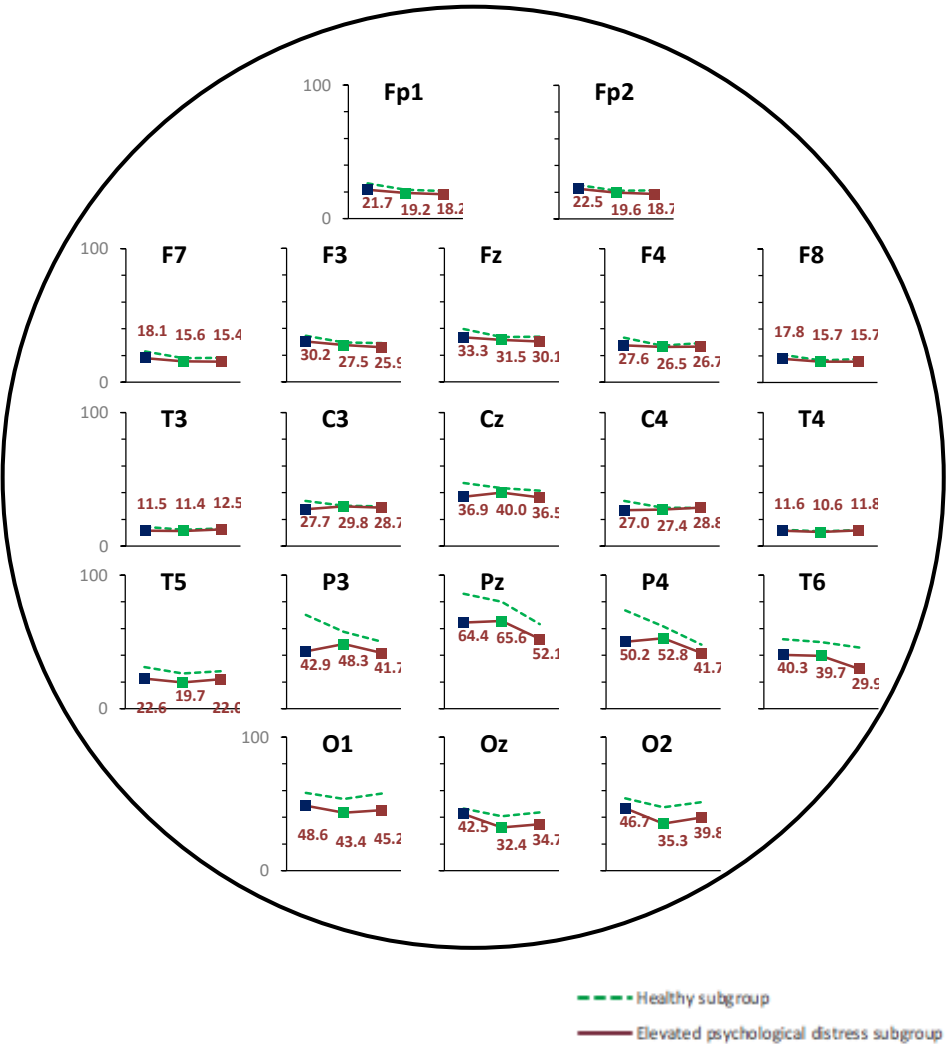
Theta power

Cohort members with elevated psychological distress recorded global average theta power reductions of 2.9% between Time 1 and Time 2. Specific reduction trends were evident at occipital and Fp2 electrodes, with marginal reductions also noted across the remaining electrodes (Fp1/F8, Cz/C4, Pz/P4 and T5/T6). Interestingly, theta power increases were evident at F7/F3/Fz, T3 and C3 electrodes, while relatively stable power levels were observed at F4, T4 and P3 electrodes. Robust theta power increases were observed between Time 2 and Time 3, with an average theta power increase of 19.8%. Power increases were observed at Fp2 and the majority of other electrodes, particularly in the left hemisphere and in more posterior regions. Trends towards slightly reduced power or stability were observed at Fp1 and T6 electrodes.

In the healthy subgroup global average theta power stayed relatively stable between Time 1 and Time 2, with a slight decrease of 0.8%. P4, T6 and the majority of frontal electrodes showed a trend toward reduction between Time 1 and Time 2, although power increases were also observed at Fp2; power increases were observed at anterior temporal, C3/Cz and P3/Pz electrodes. Power levels at Fp1, T5 and C4 remained stable.

The healthy subgroup again exhibited relatively stable theta power between Time 2 and Time 3, with an average reduction of 1.3%. Although average power levels remained quite stable, regional power changes revealed mixed trends. Power increases were observed at F8 and Oz/O2 electrodes, while sustained reduction trends were evident at O1. Power reductions were also observed at C3/Cz and P3/Pz electrodes. Power changes at C4 were notably absent for all time points. Sustained and progressive increase trends were evident at T3 and T4 electrodes. Conversely, progressive power reduction trends were evident at the remaining electrodes Fp1/Fp2/F3/Fz/F4, T5/T6 and P4. The majority of changes at all time points observed in the healthy subgroup were marginal.

Table 6.9 **Regional mean theta power levels over time in the elevated psychological distress subgroup**

Region	Time 1	Time 2	Time 3
Global	10.7	10.4	12.3
Left hem	9.3	9.3	11.3
Right hem	10.1	9.5	11
Asym [L–R]	-0.8	-0.2	0.3
Anterior	10.9	10.8	11.9
Posterior	9	8.5	10.8
AntPos [A–P]	1.8	2.3	1.2
Frontal	12.4	12.3	13.4
Left hem	11	11.2	12.5
Right hem	12	11.3	12.3
Asym [L–R]	-1	0	0.2
Central	14.7	14.4	17.6
Parietal	11.9	11.6	14.6
Temporal	6.2	6.1	7.2
Left	5.7	5.7	7.1
Right	6.7	6.5	7.2
Asym [L–R]	-1.1	-0.8	-0.1
Occipital	7.5	6.6	9

Table 6.10 **Regional mean theta power levels over time in the healthy subgroup**

Region	Time 1	Time 2	Time 3
Global	9.3	9.3	9
Left hem	8.4	8.4	8
Right hem	8.7	8.4	8.4
Asym [L–R]	-0.3	0	-0.4
Anterior	9.2	9.1	8.8
Posterior	8.5	8.3	8.2
AntPos [A–P]	0.7	0.7	0.6
Frontal	10.5	10.2	9.8
Left hem	9.7	9.5	8.9
Right hem	9.6	9.2	9.2
Asym [L–R]	0.2	0.3	-0.2
Central	11.9	12.5	12
Parietal	11	11.3	10.6
Temporal	5.6	5.6	5.6
Left	5.3	5.4	5.2
Right	5.9	5.9	6
Asym [L–R]	-0.7	-0.5	-0.7
Occipital	7.2	6.6	7.2

Figure 6.8   Mean theta power over time in the elevated psychological distress subgroup compared with the healthy subgroup
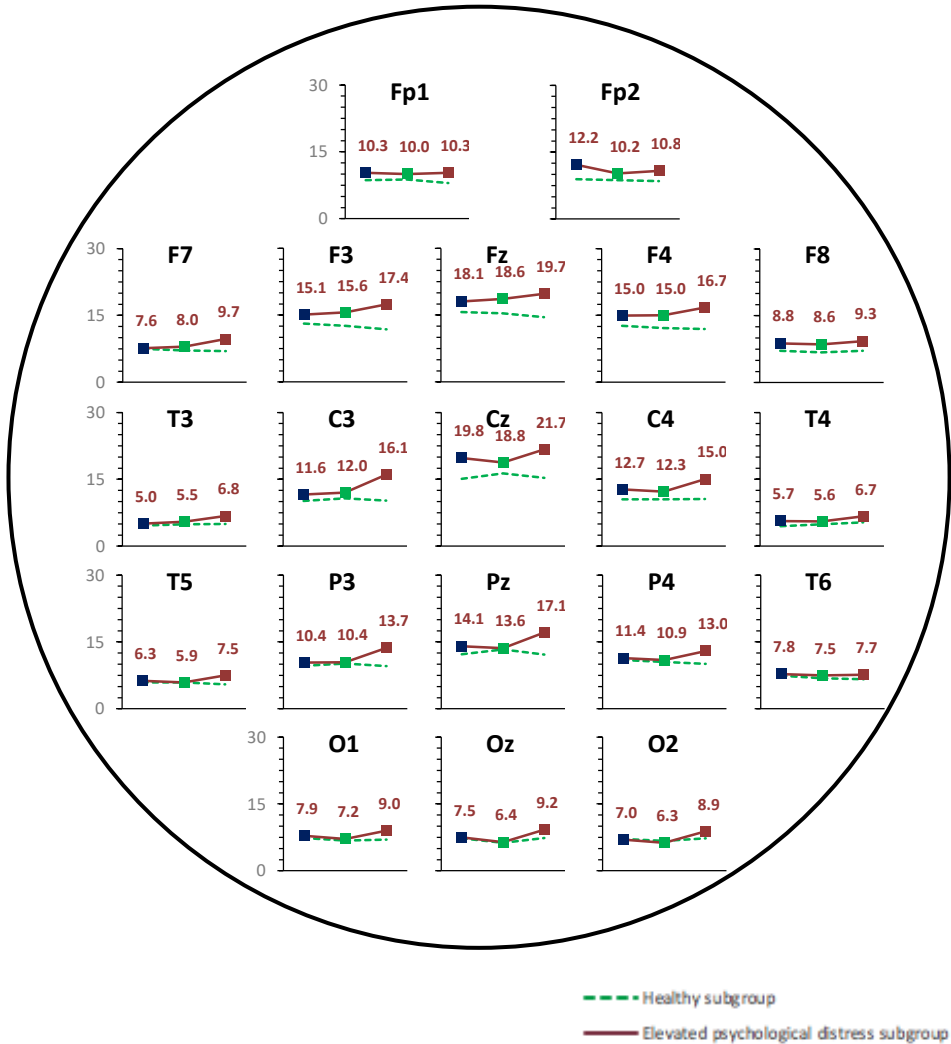
6.3.2   Working memory

Among cohort members with elevated psychological distress P3wm amplitudes were minimal at the frontal electrode and maximal at the parietal electrode at all time points. As Figure 6.9 shows, at the frontal electrode this subgroup exhibited robust amplitude increases between Time 1 and Time 2 (31.7%), followed by amplitude reductions of 28.3% between Time 2 and Time 3. Thus over time there was an overall small amplitude increase at the frontal electrode.

At the central electrode those with elevated psychological distress exhibited an amplitude increase of 6.8% between Time 1 and Time 2, followed by an amplitude reduction of 12.4% between Time 2 and Time 3, resulting in an overall amplitude reduction over time at the central electrode.

At the parietal electrode the subgroup exhibited a marginal amplitude increase of 4.1% between Time 1 and Time 2, followed by an amplitude reduction of 9.7% between Time 2 and Time 3, again resulting in an overall amplitude reduction at that electrode.

In the healthy subgroup a contrasting pattern was observed: amplitudes were maximal at the central and parietal electrodes at Time 1 and at the parietal electrode at Times 2 and 3; they were minimal at the frontal electrode at all three time points.

At the frontal electrode the healthy subgroup exhibited an amplitude reduction of 16.1% between Time 1 and Time 2, followed by an amplitude increase of 23.0% between Time 2 and Time 3. This resulted in an overall amplitude increase over time at the frontal electrode.

At the central electrode the healthy subgroup exhibited an amplitude reduction of 15.2% between Time 1 and Time 2, followed by an amplitude increase of 13.3% between Time 2 and Time 3, resulting in an overall amplitude reduction at the central electrode.

At the parietal electrode the healthy subgroup exhibited a marginal amplitude reduction of 4.1% between Time 1 and Time 2, followed by an amplitude increase of 9.2% between Time 2 and Time 3. This resulted in an overall amplitude increase at the parietal electrode.

Fz

4.4   5.8   4.1

0

Cz

8.2   8.7   7.6

0

Pz

9.6   10.0   9.0

0

- - - - Healthy subgroup

——— Elevated psychological distress subgroup
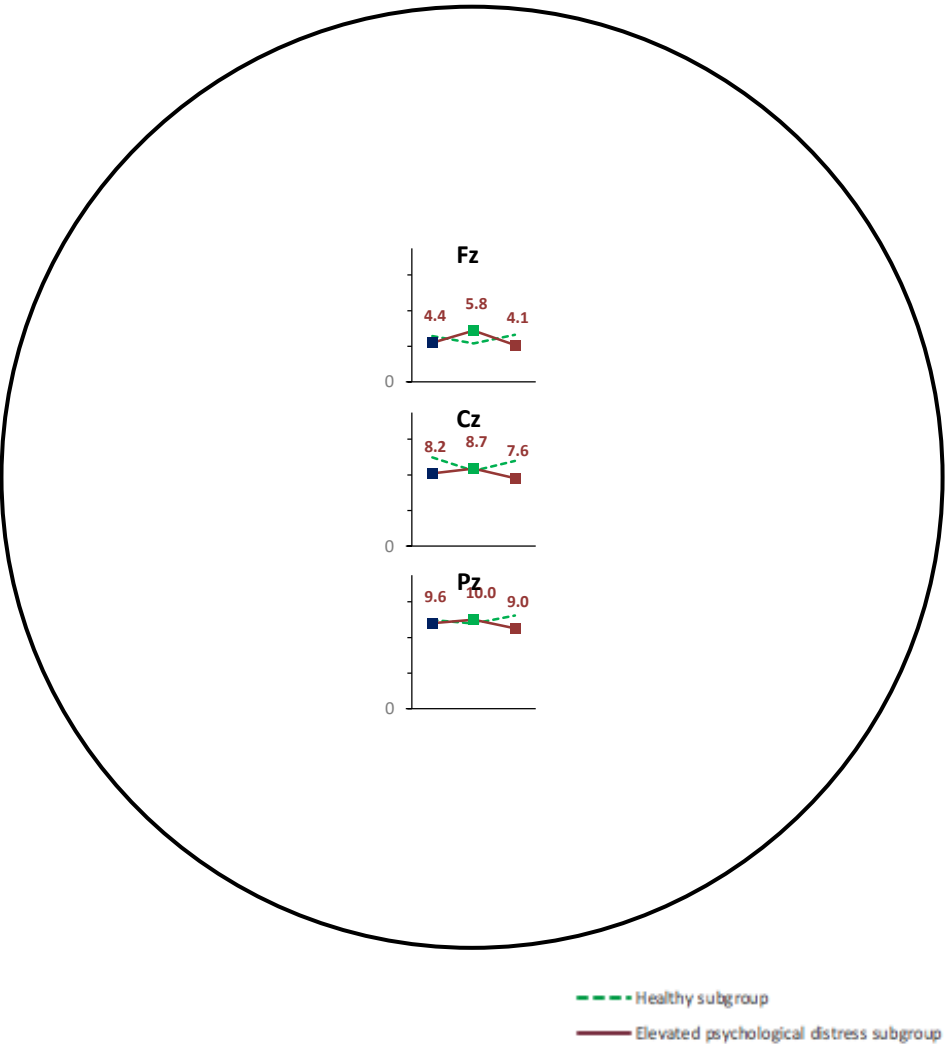
6.4   Neurocognitive function and posttraumatic stress

This section summarises trends in resting-state qEEG power levels and working memory function over time among cohort members with elevated posttraumatic stress symptoms at Time 3 (scoring above the PCL-C screening cut-off), as well as comparing them with a healthy subgroup (those scoring below K10 and PCL-C screening cut-offs at Time 3). For the purpose of these analyses, only beta, alpha and theta power levels are included under qEEG.

6.4.1 Quantitative electroencephalography

Beta power

When the full sample was divided according the presence or absence of elevated posttraumatic stress at Time 3, a difference in the pattern of change in beta power over time emerged.

Those with elevated posttraumatic stress exhibited a beta power reduction of 14.0% between Time 1 and Time 2. Notably, power increases between Time 1 and Time 2 were evident at the frontal pole and T4 electrodes (these were quite minimal, at Fp1/Fp2), while reduction trends were observed for all other electrodes, particularly in more posterior regions.

At Time 3 the elevated posttraumatic stress subgroup exhibited an average power increase of 15.3% from Time 2 levels. In contrast to the reduction seen between Time 1 and Time 2, these increases resulted in substantial power recovery, although there was an overall reduction of 2% between Time 1 and Time 3. Power levels at Fp1 remained quite stable at all time points, while power reductions were observed at T4. In contrast with these reductions, power increases were observed at left temporal, T6 and Fz electrodes, which resulted in overall power elevations between Time 1 and Time 3 at these sites.

Marginal but progressive power increases were also observed at Fp1. The O1 electrode notably exhibited progressive power decrements over time. Recovery trends were evident across all other electrodes. At Time 3 central and several frontal (F3/F4/F8) and parietal (P3/Pz) electrodes exhibited near-complete recovery to Time 1 power levels. Remaining electrodes (F7/P4/Oz/O2) exhibited partial recovery/sustained reduction trends, these being only marginal at P4.

Power levels in the elevated posttraumatic stress subgroup were higher at all three time points compared with the healthy subgroup (an average difference of 32.4%, 35.9% and 40.7%). Within-group power change trends also varied for the elevated posttraumatic stress subgroup and the healthy subgroup, with progressive increases over time in the former and progressive reductions in the latter. This pattern was particularly apparent at P3/P4 and T6 electrodes and resulted in increasing between-group differences over time. In both groups there were consistent increases in beta power over time for the vast majority of other electrodes, the frontal region also exhibiting more pronounced increases in the right versus left hemisphere at all three time points.

Table 6.11   Regional mean beta power levels over time for the elevated posttraumatic stress subgroup

Region	Time 1	Time 2	Time 3
Global	10.3	8.8	10
Left hem	9.8	8.3	9.4
Right hem	10.3	9.1	10.1
Asym [L–R]	-0.5	-0.8	-0.8
Anterior	10.1	9.5	10.3
Posterior	9.6	7.5	8.8
AntPos [A–P]	0.6	1.9	1.4
Frontal	10.6	9.8	10.6
Left hem	10.2	9.2	9.7
Right hem	10.7	10.1	10.9
Asym [L–R]	-0.5	-0.9	-1.2
Central	12.4	10.4	12.5
Parietal	10.6	8.7	10.3
Temporal	7.9	7.1	8.4
Left	7.5	5.5	8.1
Right	8.4	8.6	8.7
Asym [L–R]	-0.9	-3.1	-0.6
Occipital	10.1	7.3	8.2

Table 6.12   Regional mean beta power levels over time for the healthy subgroup

Region	Time 1	Time 2	Time 3
Global	7.8	6.5	7.2
Left hem	7.6	6.4	6.8
Right hem	7.7	6.4	7.1
Asym [L–R]	-0.1	0	-0.3
Anterior	8.1	6.9	7.8
Posterior	7.4	5.7	6.3
AntPos [A–P]	0.6	1.2	1.5
Frontal	7.9	6.9	8.3
Left hem	7.9	6.8	8
Right hem	7.8	6.8	8.1
Asym [L–R]	0.1	0	-0.1
Central	7.9	7.5	7.9
Parietal	7.9	6.5	7
Temporal	7	5.8	5.6
Left	7	6	5.1
Right	7.1	5.6	6
Asym [L–R]	-0.1	0.4	-0.9
Occipital	8.1	5.8	6.5

Alpha power

Cohort members with elevated posttraumatic stress symptoms at Time 3 had relatively stable alpha power levels between Time 1 and Time 2, with an average increase of just 1.5%. While overall alpha power was stable, however, regional power changes revealed mixed trends. Occipital and T5 electrodes exhibited power reductions between Time 1 and Time 2. F8 and T4 electrodes exhibited relatively stable power levels, while the remaining electrodes exhibited power increases between Time 1 and Time 2, particularly in the parietal region.

Those with elevated posttraumatic stress symptoms exhibited a global average alpha power increase of 5.8% between Time 2 and Time 3. These power increases were additional to the small increases observed at some sites between Time 1 and Time 2, thus resulting in progressive power elevations over time. Notably, reductions in alpha power between Time 2 and Time 3 were observed across the P3/P4 and Fz electrodes. Reductions were also observed at Pz, in contrast with the increases seen at this site between Time 1 and Time 2. Marginal increases were also evident at Cz. Stable power levels were observed for the majority of frontal electrodes (Fp1/Fp2/F7/F3/Fz/F4), resulting in sustained increased alpha power at these sites. Power increases between Time 2 and Time 3 were evident for all other electrodes. Increases at T5 resulted in near-complete recovery from Time 2 reductions. Increases were also observed at occipital electrodes, although sustained reductions remained evident. Increases at F8 and T4 electrodes resulted in overall alpha power increases over time at these sites. Additional increases at T3/T6 and C3/C4 electrodes resulted in progressive power increases at these sites too.

When compared with the pattern exhibited by the healthy subgroup (discussed in the previous section, under psychological distress), those with elevated posttraumatic stress symptoms showed contrasting patterns of change between Time 1 and Time 2 and Time 2 and Time 3. Specifically, the healthy subgroup showed a smaller reduction in alpha power between Time 1 and Time 2 and remained stable between Time 2 and Time 3, while those with elevated posttraumatic stress symptoms showed progressive decreases over time. Furthermore, contrasting power change trends were observed for non-occipital/T4 electrodes, where those with elevated posttraumatic stress symptoms recorded progressive alpha power increases while those in the healthy subgroup recorded progressive reductions.

Table 6.13   Regional mean alpha power levels over time in the elevated posttraumatic stress subgroup

Region	Time 1	Time 2	Time 3
Global	36.9	36.8	37.7
Left hem	33	31.8	34.2
Right hem	33.4	35	35.4
Asym [L–R]	-0.3	-3.2	-1.2
Anterior	22.9	24.4	24.9
Posterior	51.9	49.4	50.7
AntPos [A–P]	-29	-25	-25.7
Frontal	25.9	27.6	27.7
Left hem	24	25.7	25.8
Right hem	24.4	25.6	26.3
Asym [L–R]	-0.4	0.1	-0.6
Central	38.7	40.7	41.4
Parietal	57.1	67.1	57.6
Temporal	23.6	23.6	27.2
Left	20.9	17.3	22.3
Right	26.4	29.9	32
Asym [L–R]	-5.5	-12.7	-9.7
Occipital	58.2	42	51.3

Table 6.14   Regional mean alpha power levels over time in the healthy subgroup

Region	Time 1	Time 2	Time 3
Global	40.8	35.5	34.2
Left hem	36.5	31.2	30.9
Right hem	38.2	33	31.7
Asym [L–R]	-1.7	-1.8	-0.8
Anterior	25.6	21.3	21.7
Posterior	59	52.2	48.5
AntPos [A–P]	-33.4	-30.9	-26.8
Frontal	29.1	24	24.3
Left hem	28	23	22.7
Right hem	26.6	21.7	22.7
Asym [L–R]	1.5	1.3	0
Central	38.4	34.1	33.3
Parietal	76.5	66.4	53.7
Temporal	27.5	24.9	24.8
Left	22.8	19.4	20.7
Right	32.2	30.5	29
Asym [L–R]	-9.4	-11.1	-8.3
Occipital	52.9	47.3	50.9

Figure 6.11   Mean alpha power over time in the elevated posttraumatic stress subgroup compared with the healthy subgroup
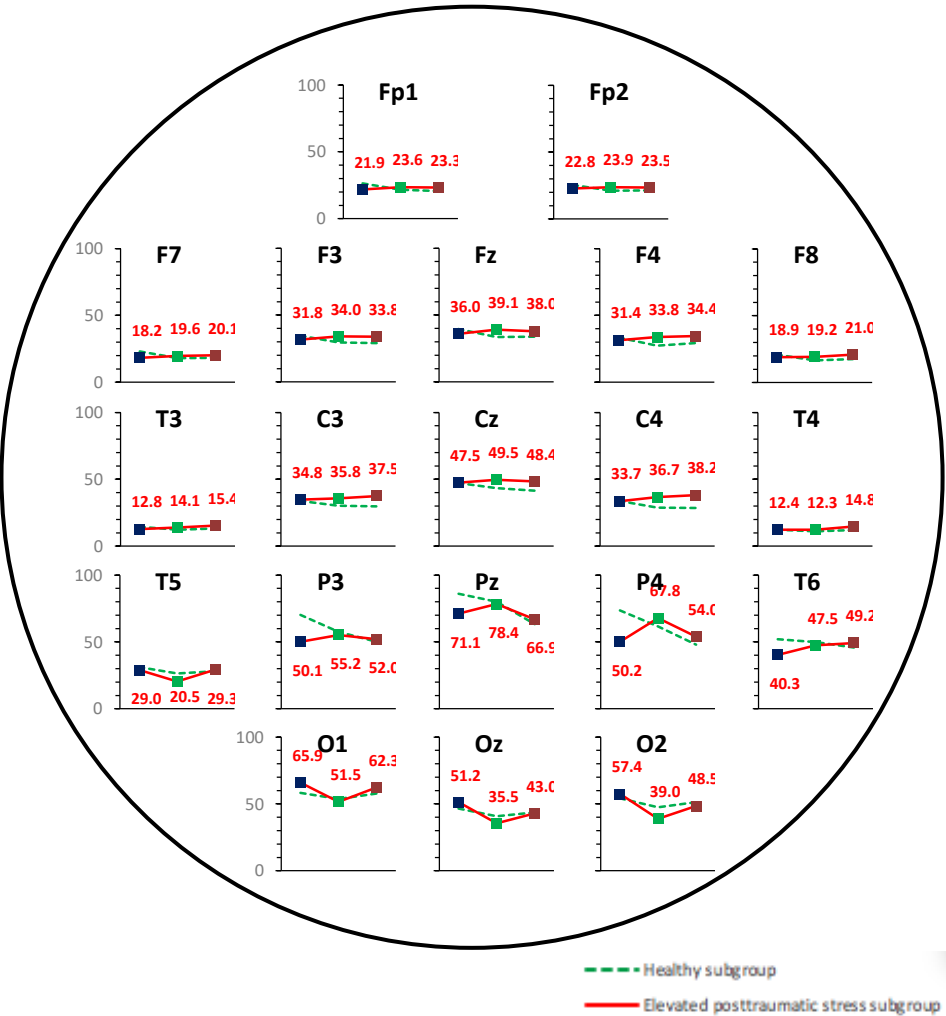
Theta power

Cohort members with elevated posttraumatic stress symptoms exhibited a marginal theta power decrease of 3.7% between Time 1 and Time 2. Reduction trends were evident at occipital and T5 electrodes, with marginal reduction also evident at F8. Relatively stable power levels between Time 1 and Time 2 were observed for the remaining electrodes (F3/Fz/F4, C3/Cz/C4 and T3). Notably, power increases between Time 1 and Time 2 were evident at the right temporal and Fp1/F7 electrodes.

Those with elevated posttraumatic stress symptoms exhibited a robust global average theta power increase of 20.3% between Time 2 and Time 3. In contrast with the decreases observed between Time 1 and Time 2, this robust increase resulted in an increase in global theta power over time. In relation to specific sites, marginal reductions in theta power between Time 2 and Time 3 were observed at Fp2, while power increases were evident at occipital and T5 electrodes and marginal at Oz. Robust increases were evident for all other electrodes, particularly in the left hemisphere.

When compared with the healthy subgroup, there were again some differences in the pattern as well as the extent of theta power change over time. Specifically, overall increases in global theta power were greater for those with elevated posttraumatic stress symptoms when compared with the increases observed in the healthy subgroup. Although those with elevated symptoms showed reduction trends between Time 1 and Time 2, the healthy subgroup remained stable. The healthy subgroup then exhibited marginal theta power reductions between Time 2 and Time 3, in contrast with the robust power increases observed for the elevated posttraumatic stress subgroup.

Table 6.15   **Regional mean theta power levels for the elevated posttraumatic stress subgroup**

Region	Time 1	Time 2	Time 3
Global	10.4	10.1	11.9
Left hem	9.1	8.9	10.8
Right hem	9.8	9.5	11
Asym [L–R]	-0.8	-0.6	-0.1
Anterior	10.6	10.6	11.9
Posterior	8.6	7.8	10
AntPos [A–P]	2	2.8	1.9
Frontal	12.1	12.1	13.5
Left hem	10.7	11.1	12.4
Right hem	11.5	11.1	12.5
Asym [L–R]	-0.8	-0.1	-0.1
Central	14.4	14.5	16.8
Parietal	11.5	11	14.1
Temporal	5.9	5.8	7.1
Left	5.4	5.1	6.7
Right	6.3	6.5	7.5
Asym [L–R]	-0.8	-1.5	-0.7
Occipital	7.2	5.8	7.6

Table 6.16   **Regional mean theta power levels over time for the healthy subgroup**

Region	Time 1	Time 2	Time 3
Global	9.3	9.3	9
Left hem	8.4	8.4	8
Right hem	8.7	8.4	8.4
Asym [L–R]	-0.3	0	-0.4
Anterior	9.2	9.1	8.8
Posterior	8.5	8.3	8.2
AntPos [A–P]	0.7	0.7	0.6
Frontal	10.5	10.2	9.8
Left hem	9.7	9.5	8.9
Right hem	9.6	9.2	9.2
Asym [L–R]	0.2	0.3	-0.2
Central	11.9	12.5	12
Parietal	11	11.3	10.6
Temporal	5.6	5.6	5.6
Left	5.3	5.4	5.2
Right	5.9	5.9	6
Asym [L–R]	-0.7	-0.5	-0.7
Occipital	7.2	6.6	7.2

Figure 6.12   Mean theta power over time in the elevated posttraumatic stress subgroup compared with the healthy subgroup
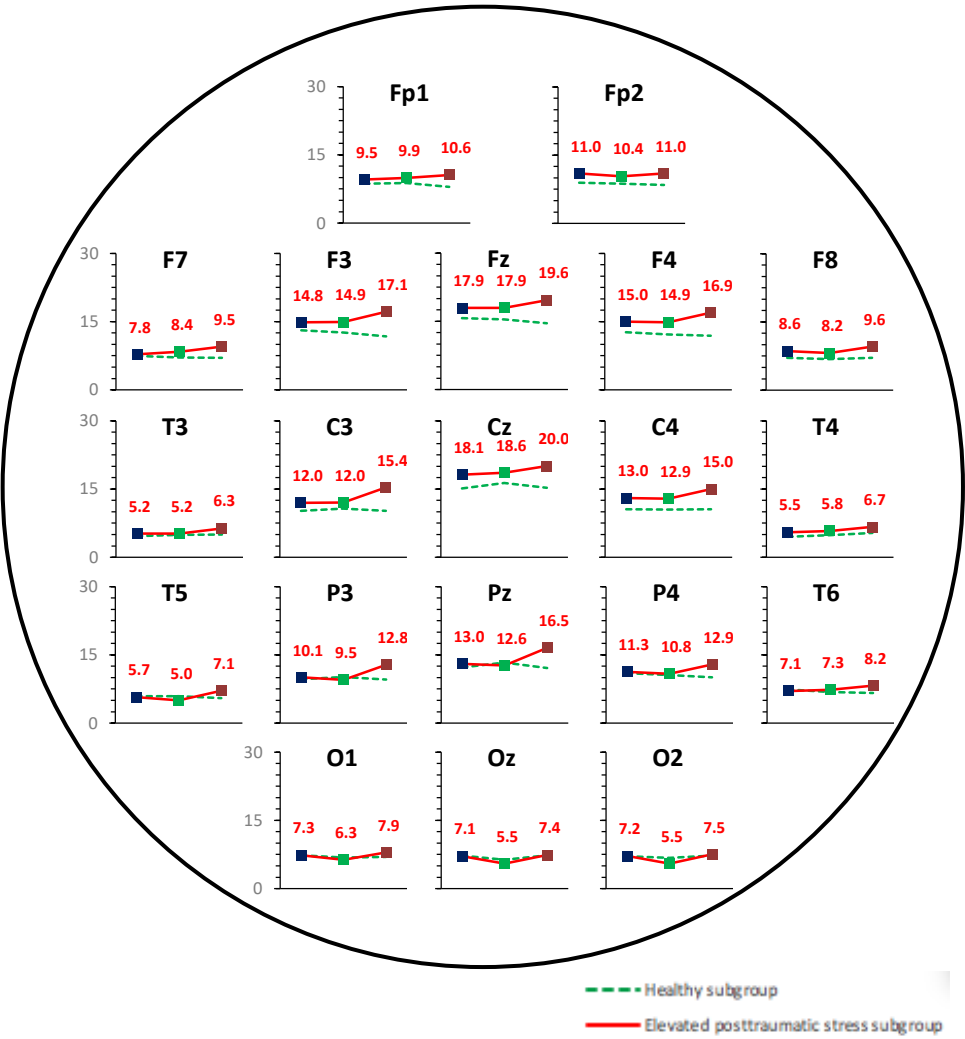
6.4.2   Working memory

Among cohort members with elevated posttraumatic stress symptoms at Time 3, P3wm amplitudes were minimal at the frontal electrode (Fz) and maximal at the parietal electrode (Pz) at all time points.

At the frontal electrode those with elevated posttraumatic stress symptoms exhibited progressive amplitude decrements over time (11.7% reduction Times 1 to 2, 16.5% reduction Times 2 to 3, and an overall reduction of 26.3% Times 1 to 3).

At the central electrode those with elevated posttraumatic stress symptoms exhibited marginal amplitude reductions between Time 1 and Time 2, followed by more pronounced reductions between Time 2 and Time 3 (2.1% reduction Times 1 to 2, 10.6% reduction Times 2 to 3, and an overall reduction of 12.4% Times 1 to 3).

At the parietal electrode those with elevated posttraumatic stress symptoms exhibited marginal amplitude reductions between Time 1 and Time 2, followed by more pronounced reductions between Time 2 and Time 3 (1.9% reduction Times 1 to 2, 7.2% reduction Times 2 to 3, and an overall reduction of 9.0% Times 1 to 3).

When compared with the healthy subgroup, those with elevated posttraumatic stress symptoms exhibited somewhat less pronounced frontal amplitude reductions between Time 1 and Time 2 and markedly more pronounced frontal amplitude reductions between Time 2 and Time 3.

When compared with the healthy subgroup, those with elevated posttraumatic stress symptoms exhibited less pronounced central amplitude reductions between Time 1 and Time 2 and somewhat more pronounced central amplitude reductions between Time 2 and Time 3.

When compared with the healthy subgroup, those with elevated posttraumatic stress symptoms exhibited lower parietal amplitudes at Time 1, comparable amplitudes at Time 2, and relatively lower amplitudes at Time 3. These shifting disparities were a result of contrasting within-group amplitude change trends. Specifically, reductions in parietal amplitudes between Time 1 and Time 2 were in contrast with only marginal reduction trends in the healthy subgroup. While those with elevated posttraumatic stress symptoms showed further parietal amplitude reductions between Time 2 and Time 3, the healthy subgroup showed amplitude increases.

Figure 6.13   Mean P3wm amplitudes over time in the elevated posttraumatic stress subgroup compared with the healthy subgroup

TRANSITION AND WELLBEING RESEARCH PROGRAMME
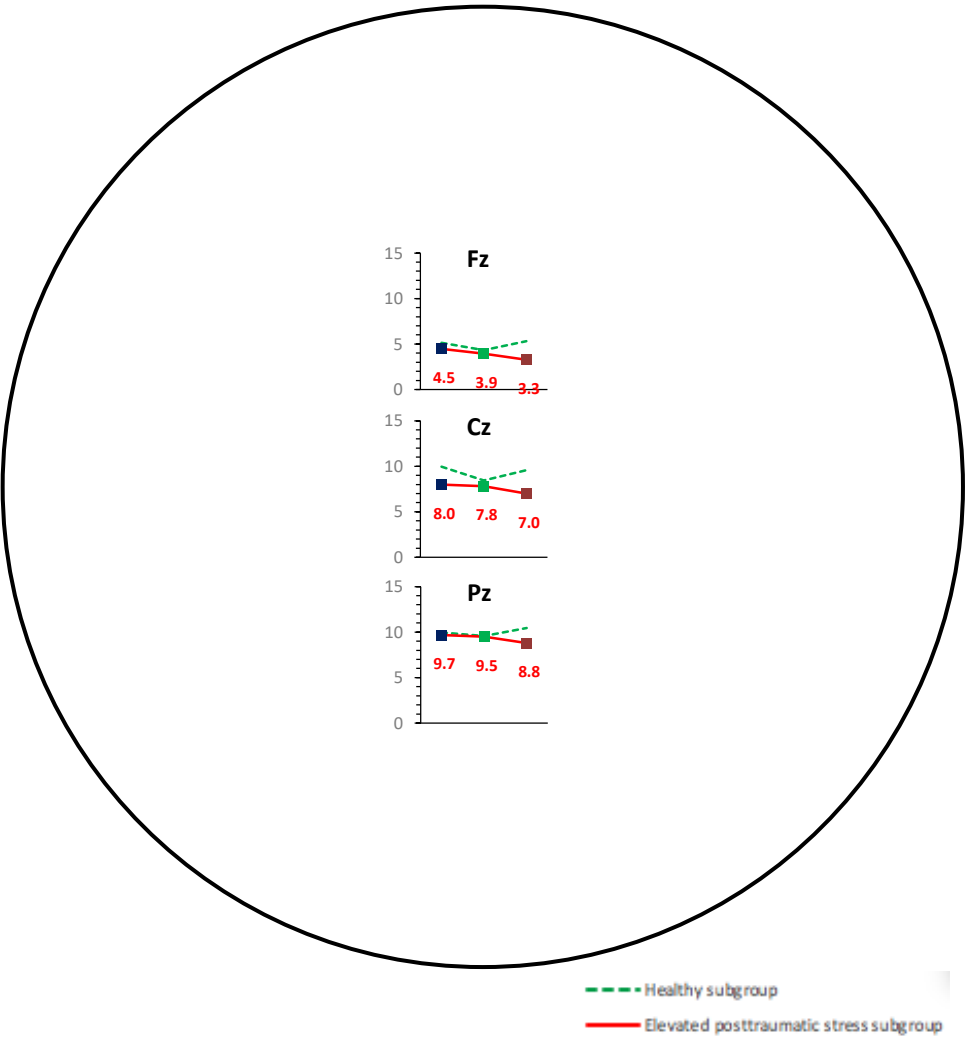
7 Detailed examination of head injury and traumatic brain injury in the MEAO Deployed Cohort

Reported head injury and traumatic brain injury in Transitioned ADF and 2015 Regular ADF members

Head injury

- With two exceptions, similar proportions of Transitioned ADF members and 2015 Regular ADF members reported experiencing all types of injuries to the head. The exceptions were injuring their head or neck in a fall/being hit by something (a lower proportion of Transitioned ADF reported this) and being nearby when an explosion/blast occurred (a greater proportion of Transitioned ADF reported this).

- Similar proportions of Transitioned ADF and 2015 Regular ADF reported that their injuries occurred during military service. A greater proportion of Transitioned ADF compared with 2015 Regular ADF reported experiencing a head injury that occurred in the context of emergency room attendance following injury to the head or neck, injuring the head or neck in a car accident/crash with another moving vehicle, or injuring their head or neck in a fight, being hit by someone, being shaken violently or being shot in the head or neck during deployment.

- The most commonly reported context for experiencing a head injury in their lifetime was being nearby when an explosion or blast occurred (Transitioned ADF, 69.7%; 2015 Regular ADF, 49.9%) and the least commonly reported context was injuring their head or neck in a fight, being hit by someone, being shaken violently or being shot in the head or neck (Transitioned ADF, 18.7%; 2015 Regular ADF, 17.0%).

Reported lifetime traumatic brain injury and mild traumatic brain injury

- Similar proportions of Transitioned ADF and 2015 Regular ADF reported experiencing any traumatic brain injury (mild, moderate or severe) in their lifetime (49.1% vs 47.4%).

- 2015 Regular ADF members reported a higher mean number of lifetime traumatic brain injuries than Transitioned ADF members (M = 4.9 vs M = 3.4).

- The great majority of reported lifetime TBI was mTBI; only four Transitioned ADF (3.7%) and 11 2015 Regular ADF (2.9%) reported moderate or severe lifetime TBI.

- A greater proportion of 2015 Regular ADF reported mTBI with loss of consciousness for less than 30 minutes (29.2% vs 19.4%) and a slightly greater proportion reported no TBI (27.1% vs 21.3%) compared with Transitioned ADF; reporting of mTBI and TBI for other categories was similar.

Mental health, functional outcomes and post-concussive symptoms in reported lifetime traumatic brain injury

- Transitioned ADF members generally had higher posttraumatic stress symptoms, psychological distress and depressive symptoms than 2015 Regular ADF members; this pattern was similar when comparing those with reported TBI and those without TBI across the two groups.

- Within both the Transitioned ADF and the 2015 Regular ADF posttraumatic stress symptoms, psychological distress and depressive symptoms were similar between those with reported TBI and those without.

- Transitioned ADF and 2015 Regular ADF who reported lifetime TBI showed slightly higher scores on total global functioning impairment compared with those with no TBI (Transitioned ADF, M = 10.7 vs M = 8.8; 2015 Regular ADF, M = 7.5 vs M = 4.9) and across all three domains of disability.

- Transitioned ADF generally had higher scores on total global functioning impairment than 2015 Regular ADF; this pattern was similar when comparing those with reported TBI and those without reported TBI across the two groups, as was seen for the psychological disorders.

- Mean post-concussive symptoms were greater in Transitioned ADF with a reported TBI (M = 6.2) compared with those with no reported TBI (M = 3.0). Mean PCS were similar in 2015 Regular ADF with a reported TBI compared with those with no reported TBI.

- Mean PCS were higher in the Transitioned ADF (for those with reported TBI and those without TBI) compared with the respective subgroups in the 2015 Regular ADF.

This chapter provides a detailed examination of head injury and TBI in the MEAO Deployed Cohort cross-sectionally at Time 3 (Impact of Combat Study). Results were also examined according to whether MEAO Deployed Cohort members had transitioned or remained in the Regular ADF at Time 3.

Head injury and TBI were assessed using a self-report version of the Ohio State University Traumatic Brain Injury Identification Method (OSU TBI-ID) (Corrigan & Bogner, 2007), which was adapted by researchers for use in the Transition and Wellbeing Research Programme. The method involves a standardised process designed to elicit an individual's lifetime history of traumatic brain injury. Participants were asked whether they had experienced a head injury in any of the following contexts in their lifetime:

- emergency room attendance following injury to head or neck

- car accident/crash with other moving vehicle causing injury to head or neck

- fall/hit by something causing injury to head or neck

- fight/being hit by someone/shaken violently causing injury to head or neck

- nearby to an explosion/blast.

If the participant responded 'yes' to any of these items they were asked questions about the frequency of the injuries, whether the injuries occurred during military service or deployment, and the number times the injuries had been sustained since 2011. Further questions were asked about symptoms experienced (for example, loss of consciousness, being dazed and confused, loss of memory), age the first and last time the symptoms occurred, frequency of symptoms, longest time knocked out or unconscious, loss of consciousness related to a drug overdose or being choked, and the occurrence of multiple blows to the head in relation to a history of abuse, contact sports or ADF training or deployment. On the basis of responses to these variables a lifetime TBI variable was calculated, comprising the following six categories:

1. No TBI

2. Head injury, but no loss of consciousness and not dazed or confused

3. Mild TBI – no loss of consciousness, but dazed or confused

4. Mild TBI – loss of consciousness less than 30 minutes

5. Moderate TBI – loss of consciousness 30 minutes to 24 hours

6. Severe TBI – loss of consciousness more than 24 hours.

This six-category variable was dichotomised into a no TBI/TBI variable, with categories 1 and 2 reflecting no mTBI and the remaining four categories reflecting TBI. The number of times participants experienced a TBI was calculated by summing their responses to the number of times they had experienced being knocked out or becoming unconscious, dazed or confused or did not remember the event as a result of the head injuries reported.

Mental health outcomes, functional impairment and post-concussive symptoms are examined as outcomes of TBI.

Three mental health outcomes are examined here: the Posttraumatic Stress Disorder Checklist – civilian version (PCL-C), K10 and the Patient Health Questionnaire (PHQ-9). (These are discussed in detail elsewhere in the report.) Mean total scores are presented.

Functional impairment was assessed via the Sheehan Disability Scale (Sheehan, 1983), a five-item self-report measure of disability resulting from mental health symptoms in three interrelated domains – work, social life and family life. The three items assessing

impairment in the three domains were scored from zero to 10 and summed to yield a total global functional impairment score of between zero and 30.

Post-concussive symptoms were measured using a modified version of the Post-concussion Syndrome Checklist (Gouvier et al., 1992), which was used as part of the 2012 MEAO Prospective Study (Davy et al., 2012). This modified version of the scale required participants to indicate the degree to which they had experienced a list of 11 symptoms (anxiety, headaches, dizziness, fatigue, visual problems, sensitivity to noise, ringing in the ears, memory, concentration, judgment problems, irritability) in the preceding four weeks as a result of an injury to their head or neck. The items were rated on a five-point scale from 0 'not at all' to 4 'extremely'. A total post-concussive symptom score was calculated by summing the scores for these 11 items.

7.1   Injuries to the head

Table 7.1 shows the frequencies of self-reported TBI and head injury in Transitioned ADF and 2015 Regular ADF in the MEAO Deployed Cohort and whether they occurred during military service and during deployment.

Similar proportions of Transitioned ADF (36.1%) and 2015 Regular ADF (41.7%) reported lifetime emergency room attendance following a head or neck injury. Of these, similar proportions of Transitioned ADF (51.3%) and 2015 Regular ADF (48.1%) reported the injury was related to military service, although Transitioned ADF were more likely to report that it was sustained during deployment (23.1% vs 9.4%).

Both groups were less likely to report injuring the head or neck in a car accident or crash with another moving vehicle (Transitioned ADF, 15.6%; 2015 Regular ADF, 17.5%). Similar proportions of Transitioned ADF (47.1%) and 2015 Regular ADF (46.3%) reported that this occurred during military service but, again, higher proportions of Transitioned ADF reported that this occurred during deployment (17.6% vs 9.0%).

More 2015 Regular ADF (40.7%) reported injuring their head or neck in a fall or from being hit by something compared with Transitioned ADF (30.6%). Similar proportions of Transitioned ADF and 2015 Regular ADF reported that this occurred during military service (39.4% vs 41.0%) or on deployment (6.1% vs 4.5%).

Comparatively low levels reported injuring their head or neck in a fight or being hit by someone, shaken violently or shot in the head or neck (Transitioned ADF, 18.7%; 2015 Regular ADF, 17.0%). Similar proportions of Transitioned ADF and 2015 Regular ADF reported that this occurred during military service (45.0% vs 47.7%) but higher proportions of Transitioned ADF reported that this occurred during deployment (15.0% vs 7.7%).

The highest reported proportions were for being nearby when an explosion or blast occurred, for which Transitioned ADF (69.7%) reported much higher levels than 2015 Regular ADF (49.9%). Of those reporting this, similar proportions of Transitioned ADF and 2015 Regular ADF reported it was during military service (86.8% vs 92.1%) and during deployment (76.3% vs 72.8%).

Table 7.1   **Frequencies of self-reported injuries to the head in Transitioned ADF and 2015 Regular ADF in the MEAO Deployed Cohort**

Lifetime injuries to head/neck	Transitioned ADF n = 109		2015 Regular ADF n = 384	
	n	% (95% CI)	n	% (95% CI)
Emergency room attendance following injury to head/neck	39	36.1 (27.1–45.2)	160	41.7 (36.7–46.6)
During military service	20	51.3 (35.6–67.0)	77	48.1 (40.4–55.9)
During deployment	9	23.1 (9.9–36.3)	15	9.4 (4.9–13.9)
Car accident/crash with other moving vehicle causing injury to head/neck	17	15.6 (8.8–22.4)	67	17.5 (13.7–21.3)
During military service	8	47.1 (23.3–70.8)	31	46.3 (34.3–58.2)
During deployment	3	17.6 (0.0–35.8)	6	9.0 (2.1–15.8)
Fall/hit by something causing injury to head/neck	33	30.6 (21.9–39.2)	156	40.7 (35.8–45.7)
During military service	13	39.4 (22.7–56.1)	64	41.0 (33.3–48.7)
During deployment	2	6.1 (0.0–14.2)	7	4.5 (1.2–7.7)
Fight/being hit by someone/shaken violently causing injury to head/neck	20	18.7 (11.3–26.1)	65	17.0 (13.2–20.8)
During military service	9	45.0 (23.2–66.8)	31	47.7 (35.5–59.8)
During deployment	3	15.0 (0.0–30.6)	5	7.7 (1.2–14.2)
Nearby to an explosion/blast	76	69.7 (61.1–78.4)	191	49.9 (44.9–54.9)
During military service	66	86.8 (79.2–94.4)	176	92.1 (88.3–96.0)
During deployment	58	76.3 (66.8–85.9)	139	72.8 (66.5–79.1)

7.2   Probable traumatic brain injuries

Table 7.2 shows lifetime TBI in Transitioned ADF and 2015 Regular ADF in the MEAO Deployed Cohort. Overall, similar proportions of Transitioned ADF and 2015 Regular ADF reported experiencing a TBI in their lifetime (49.1% vs 47.4%).

Transitioned ADF and 2015 Regular ADF generally showed similar distributions of severity on the six-category lifetime TBI variable. Slightly more Regular ADF reported no TBI (27.1% vs 21.3%) and mild TBI with loss of consciousness (LOC) less than 30 minutes (29.2% vs 19.4%) and slightly more Transitioned ADF reported mild TBI with no LOC but were dazed or confused. Moderate and severe TBI were uncommon, with 2.8% of Transitioned ADF and 2.1% of 2015 Regular ADF reporting moderate TBI and 0.9% of Transitioned ADF and 0.8% of 2015 Regular ADF reporting severe TBI.

2015 Regular ADF members reported a higher mean number of TBIs than Transitioned ADF members (M = 4.9 vs M = 3.4).

Table 7.2   Lifetime traumatic brain injury in Transitioned ADF and 2015 Regular ADF in MEAO Deployed Cohort

Lifetime TBI	Transitioned ADF n = 108		2015 Regular ADF n = 384	
	n	% (95% CI)	n	% (95% CI)
No TBI	23	21.3 (13.6–29.0)	104	27.1 (22.6–31.5)
Head injury, but no LOC and not dazed or confused	32	29.6 (21.0–38.2)	98	25.5 (21.2–29.9)
Mild TBI – no LOC but were dazed or confused	28	25.9 (17.7–34.2)	59	15.4 (11.8–19.0)
Mild TBI – LOC <30min	21	19.4 (12.0–26.9)	112	29.2 (24.6–33.7)
Moderate TBI – LOC 30min–24hr	3	2.8 (0.0–5.9)	8	2.1 (0.7–3.5)
Severe TBI – LOC (> 24hr)	1	0.9 (0.0–2.7)	3	0.8 (0.0–1.7)
Dichotomous (any TBI vs no TBI)	53	49.1 (39.6–58.5)	182	47.4 (42.4–52.4)
Number of times TBI (M, SE)		3.4 (0.5)		4.9 (0.5)

Table 7.3 shows mean self-reported mental health, functioning and post-concussive symptoms by lifetime TBI status in Transitioned ADF and 2015 Regular ADF in the MEAO Deployed Cohort.

Those reporting a lifetime TBI showed little difference on mental health outcomes (PCL-C, K10, PHQ) compared with those with no TBI in both Transitioned ADF and 2015 Regular ADF. 2015 Regular ADF with a TBI had slightly higher mean scores on the PCL-C compared with those with no history of TBI (M = 25.5 vs M = 22.5).

Both Transitioned ADF (M = 10.7) and 2015 Regular ADF (M = 7.5) with a TBI showed slightly higher scores on total global functioning impairment compared with those with no TBI (M = 8.8 and M = 4.9). This pattern was evident for both groups in all three domains, but it was most apparent in relation to disrupting work for Transitioned ADF (M = 3.0 vs M = 2.2) and disrupting social life and leisure activities for 2015 Regular ADF (M = 2.8 vs M = 1.6).

Mean post-concussive symptoms were noticeably higher in Transitioned ADF with a TBI (M = 6.2) compared with those with no history of TBI (M = 3.0). Scores were similar for the 2015 Regular ADF.

Table 7.3   Mean outcomes by lifetime TBI in Transitioned ADF and 2015 Regular ADF in MEAO Deployed Cohort

| | Transitioned ADF n = 108 | | | | 2015 Regular ADF n = 384 | | | |
| | No TBI n = 55 | | Any TBI n = 53 | | No TBI n = 202 | | Any TBI n = 182 | |
Outcome	M	SE	M	SE	M	SE	M	SE
PCL-C	33.3	2.5	33.9	2.4	22.5	0.6	25.5	0.7
K10	20.5	1.7	20.1	1.4	15.1	0.7	16.9	0.7
PHQ	7.1	1.1	8.3	1.0	3.8	0.3	4.9	0.4
Total global functional impairment	8.8	1.2	10.7	1.3	4.9	0.5	7.5	0.6
Disrupt work	2.2	0.4	3.0	0.5	1.4	0.2	2.2	0.2
Disrupt social life and leisure activities	3.4	0.4	3.8	0.4	1.6	0.2	2.8	0.2
Disrupt family life and home responsibilities	3.2	0.5	3.8	0.4	1.8	0.2	2.6	0.2
Post-concussive symptoms	3.0	1.1	6.2	1.3	1.4	0.3	2.0	0.3

8 Pilot neuroimaging investigation of white matter integrity

A pilot neuroimaging investigation was performed on a subset of the Combat Role High-risk Subgroup, examining white matter integrity in relation to injuries to the head, self-reported TBI and a range of other factors. It is important to understand that the aim of this pilot investigation was to understand the feasibility of conducting neuroimaging investigations of mTBI and combat exposure in Regular and transitioned ADF members. It was not the intention to conduct a definitive study; rather, a proof-of-concept approach was adopted to determine such a study's acceptability and feasibility and to explore possible avenues for future investigation of neural effects of mTBI. To have sufficient statistical power to conduct this study in a way that allows firm inferences to be drawn would require recruitment of hundreds of ADF members, which would be extremely costly and resource-intensive for personnel as well as Defence and DVA. Accordingly, the outcomes of this pilot investigation should be interpreted very cautiously and should not be considered indicative of any causal relationship between alterations in brain structure and mTBI or combat exposure.

8.1 Methodology

8.1.1 Image acquisition

Magnetic resonance imaging used a 3.0T General Electric (Milwaukee, Wisconsin) Signa HDx scanner with an eight-channel head coil. T1-weighted three-dimensional (3-D) spoiled gradient recalled parameters included 180 sagittal 1 mm 3 slices, 1 mm isotropic, 256 _ 256 matrix, repetition time = 8.3 msec, echo time = 3.2 msec, flip angle = 11°, and inversion time = 500 msec. Freesurfer (v4.3) (http://surfer.nmr.mgh.harvard.edu/) was used for segmentation of the 3-D T1-weighted structural images. In brief, a two-dimensional cortical surface was calculated and automatically divided into 35 gyralbased anatomically labelled areas for each hemisphere using the Desikan–Killiany atlas. An automatic subcortical parcellation was also performed based on probabilistic information on location of subcortical structures automatically estimated from a manually labelled training dataset. Cortical segmentation and anatomical labels were validated by manual inspection.

A spin-echo DTI-Echo Planar Imaging sequence was used to acquire diffusion-weighted images (DWIs). Seventy contiguous axial, 2.5 mm–thick slices (providing whole brain coverage) were acquired in 42 gradient directions with a b value of 1250 s/mm2. The imaging parameters were as follows: TR, 17000 ms; TE, 95 ms; fat saturation, ON; NEX,

1; frequency direction, R/L; in-plane resolution, 1.72 mm x 1.72 mm, 128 x 128 matrix. Four baseline (b = 0) images were acquired at the start of the sequence and were used in the diffusion-tensor image tensor fit.

Slicer 3D software was used to analyse the DWIs to identify and measure tracts of interest. DWIs were first converted to diffusion-tensor images on the basis of a least-squares estimation. Two diffusion metrics were calculated from the DTIs: fractional anisotropy (FA) and mean diffusivity (Mori, 2007; Shenton & Turetsky, 2010). A fiducial-based tractography approach was used to identify and extract the tracts of interest. Colour-by-orientation images were used in order to position fiducials within the regions of interest, which were identified using previously described anatomical references (Catani & De Schotten, 2008; Oishi et al., 2010). Cronbach's alphas for the inter- and intra-rater reliabilities were both excellent, measuring .928 and .922 respectively. This report describes the findings in relation to two indices of DTI – fractional anisotropy and mean diffusivity, where the former is used as an estimate of the degree of preferred direction and the latter describes average diffusion (Song et al., 2003).

8.1.2   Participants

Thirty-four Transitioned and 2015 Regular ADF members who were part of the Combat Role High-risk Subgroup, who had undergone neurocognitive assessments at Time 1 and/or Time 2 as part of the MEAO Prospective Study, and who had deployed to the MEAO in active combat roles were recruited for the study. A major focus was to assess ADF members who had been exposed to high levels of combat; accordingly, all participants had been deployed to active service in the Middle East and had been exposed to combat.

8.1.3   Measures

The self-report measures used in the analyses were psychological distress, posttraumatic stress, post-concussive symptoms, exposure-related factors and working memory.

Psychological distress

Psychological distress was measured using the K10. This commonly used measure is a 10-item screening questionnaire for psychological distress that was developed for use in the US National Health Interview Survey (Kessler et al., 2002). Originally designed as a short, easily administered screen for psychological distress, the K10 is typically used to inform and complement clinical interviews and to quantify levels of distress in those who need treatment. The ADF uses it for mental health screening.

Responders were instructed to rate the amount of time they had experienced one of 10 emotional states during the preceding four weeks (for example, being tired for no

good reason; feeling nervous, hopeless or depressed). The 10 questions are scored 1 to 5, and the responder must indicate how often they have felt that way, using the following response options: 'all of the time' (5), 'most of the time' (4), 'some of the time' (3), 'a little of the time' (2) or 'none of the time' (1). The scores for the 10 questions are then added up to give a total score of 10 to 50. For the purposes of identifying probable disorder, an epidemiological cut-off score of 25 was adopted.

Posttraumatic stress

To index posttraumatic stress symptom severity, the 17-item Posttraumatic Stress Disorder Checklist (PCL) was used (Weathers et al., 1993). Responses are scored 1 to 5 and added up to give a total score from 17 to 85. Responders were instructed to indicate how much they were bothered by each symptom in the preceding month using one of five response options – 'not at all' (1), 'a little bit' (2), 'moderately' (3), 'quite a bit' (4), 'extremely' (5). The 17–item PCL was used instead of the PCL-5 (from the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*) to allow comparison with the 2010 Regular ADF cohort. Additional questions relating to DSM-5 PTSD were included in the survey but are not discussed here. To identify probable PTSD, an epidemiological cut-off score of 53 was adopted.

Post-concussive symptoms

Post-concussive symptoms were assessed using a modified version of the Post-concussion Syndrome Checklist (Gouvier et al., 1992), which had been used as part of the 2012 MEAO Health Study (Davy et al., 2012). This modified version of the scale required participants to indicate the degree to which they had experienced a list of 11 symptoms in the preceding four weeks as a result of an injury to their head or neck.

Exposure-related factors

Two variables were considered to represent the extent to which personnel were exposed to conditions that might affect neural structure or integrity. Participants were asked whether they had experienced an injury to their head or neck in any of five contexts in their lifetime – emergency room attendance following injury to head or neck, car accident/crash with other moving vehicle causing injury to head or neck, fall/hit by something causing injury to head or neck, fight/being hit by someone/shaken violently causing injury to head or neck, and nearby to an explosion/blast. If the participant responded 'yes' to any of these items they were asked questions about the frequency of these injuries, whether the injuries occurred during military service or during deployment, and the number times since 2011. First, an overall exposure score was calculated by summing the number of times for the five items. Second, to identify the extent to which personnel might have been directly exposed to blast/explosive events (which have the potential to adversely affect neural structure or microstructure), the self-reported estimate responders provided on how

many times they were exposed to blast/explosive events specifically was also examined.

Working memory

This study focused on the capacity to hold information in short-term memory store to allow ongoing information processing, including decision making. Functional working memory is essential for many core cognitive functions, and impaired working memory is associated with both mTBI (Konrad et al., 2011; Massey et al., 2015) and PTSD (Koso & Hansen, 2006; Park et al., 2014). Moreover, alterations in cortical structure are associated with depleted working memory capacity (Urban et al., 2017).

8.1.4   Data analysis

As discussed, the lack of a comparison group in the study design precludes comparative analyses with non-exposed personnel. Analyses therefore focused on associations between structural and microstructural patterns and responses on the psychological and exposure-related indices assessed. To identify potential associations, Pearson correlation coefficients were calculated between each variable of interest.

It is crucial to note that identifying an effect as statistically significant requires that the effect is not due to chance. There are two aspects of this study that require cautious interpretation of the results because of the need to achieve satisfactory statistical significance. First, each time one does a comparison there is a greater chance of finding a significant result. This means that one needs to adjust the level of significance such that a finding is truly significant and not a result of chance. Convention in research holds that statistical tests need to be significant at the .05 level, meaning that there is only a 5% chance that the result is due to chance. If two analyses are conducted, however, a more stringent level is required and the level is adjusted to .025. In this study there are many comparisons between different brain regions and the self-report measures obtained from personnel. In order to maintain scientific rigour, therefore, the study adopted a level of <.001 to determine significance.

The second factor that needs to be considered in relation to interpretation of this study's results is that the sample size is very small. Although a sample size of 34 is not uncommon in neuroimaging research, it typically occurs in the context of a comparison condition. The sample size raises the strong possibility that results could easily change if another 10 or 20 participants were added to the sample. This leads to the conclusion that even statistically significant findings need to be considered very cautiously.

8.2   Results

8.2.1   Participant characteristics

Thirty-two males and two females participated in the study. Their average age was 32.45 years (SD = 6.32; range, 25–49 years). Notably, 19 (55.9%) of the participants were Special Forces (the relevance of this is discussed later). The mean score for the K10 was 12.29 (SD = 2.94), and for the PCL the mean score was 19.61 (SD = 5.94). Importantly, in this sample no participant scored above the ADF cut-offs for probable disorder on either the K10 or the PCL.

8.2.2   Relationships between blast or explosion exposure and brain structure

There was a significant negative correlation between the number of times participants reported being exposed to blasts or explosions and the thickness of the left precentral gyrus (r = –.70, p <.001). That is, the more participants reported being exposed to blasts or explosions, the thinner the left precentral gyrus. There were no associations with white matter integrity.

8.2.3   Relationships between psychological distress, PTSD or post-concussive symptoms and brain structure

There were no significant correlation coefficients between psychological distress, posttraumatic stress or post-concussive symptoms and any of the measures of brain structure or white matter integrity.

8.2.4   Relationship between combat exposures and brain structure

There were no significant correlation coefficients between any of the indices of combat exposure and any of the measures of brain structure or white matter integrity.

8.2.5   Relationships between working memory and brain structure

There were no significant correlation coefficients between working memory and any of the measures of brain structure or white matter integrity.

9 Discussion

9.1 Background

This report presents the results of the initial analysis of the Impact of Combat Study, which represents the third wave of data collection on the cohort from the MEAO Prospective Study. It maps the longitudinal trajectory of the health of this population, who were exposed to significant levels of combat while on deployment to the Middle East Area of Operations. The aim of the current follow-up was to document the health of this cohort – those who continued to serve as well as those who had transitioned from full-time ADF service. In addition to documenting self-reported mental and physical health symptoms in the entire cohort over time, the study captured objective measures of biological health and cognitive function in targeted subgroups of the cohort. As well as reporting on the change in these health outcomes over time, the contribution of various factors to longer term symptomatic distress was also explored. Furthermore, an investigation of traumatic brain injury in the cohort and a pilot neuroimaging study in a select subset of the cohort were also conducted. The discussion that follows deals with each of these study components.

9.2 Methodological considerations and population characteristics

In understanding the study findings and in interpreting the data it is important to understand the study methodology. In particular, unlike cross-sectional studies, in a prospective design such as this individuals formed their own controls, allowing change to be tracked across time. This strength can minimise some of the problems that arise as a result of participant attrition in longitudinal studies that do not have pre-exposure measures. Furthermore, because data were collected on the participants before their index deployment, the specific effects of deployment can be separated from any antecedent risk factors.

A clear limitation in this study was the response rate. Survey responders were defined as those who had completed at least the demographics section of the Impact of Combat survey. Of the 1350 members of the cohort who participated in the MEAO Prospective Study (Times 1 and 2), for the survey component of the study there was a response rate of 26.5% for the Transitioned ADF and 49.9% of the 2015 Regular ADF at Time 3. There were substantial between-group differences for some demographic and Service groups for the Transitioned ADF and 2015 Regular ADF. One of the implications of this is the potential for bias, especially in low-participation groups, but there was no formal examination of participation bias in the study. The low participation rate also

meant that numbers of cases for some health outcomes of interest were small, so there was limited statistical power to investigate differences between groups in such outcomes, and in the study populations directly, compared with what might have been achieved had there been a higher participation rate.

The response rates in this study demonstrated that it was much more difficult to engage the Transitioned ADF population (26%) compared with those who remained in the Regular ADF (50%). This difficulty replicates the experience of the MEAO Census Study (Dobson et al., 2012), where there was a substantially lower participation rate among those no longer in active service. Another group who were more difficult to engage in the current study were those in the lower ranks (9.9% Other Ranks vs 63.4% NCOs). Since this was a cohort follow-up, however, it was expected that there would be more individuals in higher ranks at this data collection point, promotions occurring with the passage of time. Additionally, these potential sources of bias – transition and low rank tend to be associated with poorer health status – were countered by the observation that the medical fitness classification of both responders and non-responders in the study were similar.

The demographic characteristics of this population are also important to interpretation of the results. Age is generally associated with decreases in the 12-month prevalence rates of mental disorders (Slade et al., 2009), so the ageing of this cohort would generally be expected to be associated with a declining rate of psychological distress. By the time of completing the study, those who remained in the Regular ADF were slightly older than those who had transitioned (M = 38.1 years vs M = 35.6 years), although they were still relatively young. Those who remained in the ADF also had a significantly longer duration of service: while only 20.7% of the entire cohort had served for less than eight years, this was the case for nearly half of those who had transitioned. In general, all cohort members reported stable social circumstances, the majority (68%) being in a relationship or living with a partner. As anticipated from the findings in the *Mental Health Prevalence Report* (Van Hooff et al., 2018), however, the transitioned sample were experiencing greater degrees of social dislocation, with 71.3% being in full- or part-time work and 10% reporting being on some form of pension or compensation. This is consistent with the observation that 8.7% had been medically discharged. When considering their access to health care and DVA support, one in three reported treatment support of some form (White or Gold Card, 34.8%), highlighting the level of health care need in this population.

9.3   Mental health over time

As was expected, the study findings showed that cohort members who had transitioned were experiencing significantly worse mental health than members who remained in the Regular ADF. This is not surprising given the findings from the earlier

Mental Health Prevalence Report (Van Hooff et al., 2018). Furthermore, it is likely that the result reflects a 'healthy worker' effect, which is not unexpected. Importantly, when considered together, for all mental health measures there were small to moderate increases in symptoms over time and correspondingly small to moderate increases in the proportion of the cohort with subsyndromal or probable disorder at Time 3.

Against this background, an important finding is that for all the mental health measures there was a significant increase in the proportion of the cohort scoring above the screening and epidemiological cut-offs with the passage of time. In the case of depression, at Time 3 one-third of cohort members were reporting symptom levels consistent with subsyndromal (27.9%) or probable disorder (5.4%), the greatest change occurring between Time 2 and Time 3. For the K10 measure of psychological distress, a different pattern was observed: the proportion of the cohort with probable psychological distress did not change between Time 1 (3.7%) and Time 2 (4.0%) but increased dramatically at Time 3 (14.0%). In contrast, the proportion with subsyndromal distress was relatively stable across time. This suggests that a significant number of members with subsyndromal distress had further increases in symptoms as time passed, moving into probable disorder and accounting for the sharp increase in the proportion with probable disorder at Time 3. In the case of PTSD, the proportion of the cohort with subsyndromal posttraumatic stress symptoms nearly doubled from Time 1 (7.1%) to Time 2 (13.4%) and increased again, to 21.7%, at Time 3. The proportion of the cohort with probable PTSD was generally very low but showed the same pattern of increase over time (Time 1, 0.2%; Time 2, 1.7%; Time 3, 3.6%).

These findings highlight a general pattern of increasing symptomatic distress for all measures over time. This is consistent with the phenomenon of time-dependent sensitisation, which is characterised by increasing reactivity with time and difficulty in modulating distress (McFarlane, 2010b). Sensitisation is discussed in further detail later in this chapter.

9.4   Subsyndromal distress

Importantly, the results just presented underscore the significance of subsyndromal symptoms as an indicator of risk for future progression to diagnosable disorder. The 2010 Mental Health Prevalence and Wellbeing Study (McFarlane et al., 2011b) similarly identified the predictable trajectory from subsyndromal symptoms to disorder across the spectrum of mental health measures. These findings also highlight the importance of early identification of symptoms of depression, psychological distress and PTSD in particular.

The pattern of symptom recruitment over time is consistent with a substantial body of literature identifying subsyndromal PTSD as a major risk factor for the later emergence of diagnosable disorder (Smid et al., 2009). An extensive study of Israeli veterans of the 1983 Lebanon War emphasised that, while in general PTSD emerged relatively soon in the aftermath of the war, it again peaked much later – 17 years after the period of military service (Solomon & Mikulincer, 2006). In fact, 23% of those veterans who did not develop an immediate acute stress disorder subsequently developed delayed-onset PTSD. Similarly, in the Australian Vietnam Veterans Study rates of lifetime PTSD were found to increase over a decade, going from 20% in the 1990s to 28% in the 2000s (O'Toole et al., 2009). Subthreshold PTSD symptoms have also been found to be associated with development of anxiety and depression over time (Lawrence-Wood et al., 2016). As with posttraumatic stress symptoms, there is also evidence that subthreshold depressive symptomatology is an important predictor of emerging anxiety and depressive disorder (Karsten et al., 2011).

It has further been recognised that subsyndromal symptoms in their own right represent a significant risk in terms of impairment and constitute an important focus for clinical intervention despite not satisfying the full diagnostic criteria (Kornfield et al., 2012). Subsyndromal PTSD in particular has been found to be associated with significant health-related difficulties and functional impairment (Pietrzak et al., 2009). For example, among a cohort of emergency service workers, four years after the World Trade Centre collapse in 2001, 5.4% had full PTSD whereas 15.4% had subsyndromal PTSD. Importantly, both full PTSD and subsyndromal PTSD were significantly associated with alcohol abuse and somatic symptoms. Pietrzak et al. (2012) concluded that it was important to have a dimensional perspective of PTSD 'as operational definitions and conventional screening cut points may under estimate the psychological burden for this population'.

In addition to these considerations, the increasing levels of subsyndromal distress observed in this cohort occur alongside a corresponding increase in suicidality, alcohol use and anger. The proportion of the cohort with any suicidality increased slightly from Time 1 (2.2%) to Time 2 (3.6%) then increased dramatically by Time 3 (12.7%). As was found in the 2010 Mental Health Prevalence and Wellbeing Study (McFarlane et al., 2011b), there were generally low rates of probable alcohol disorder in the Combat Study cohort, yet there still was a pattern of increase over time (Time 1, 0.7%; Time 2, 1.9%; Time 3,: 2.9%). The low rates of alcohol use observed here contrast with the findings of elevated alcohol use – particularly in ADF members who had transitioned from Regular ADF Service – that were presented in the *Mental Health Prevalence Report* (Van Hooff et al., 2018). The lower rates observed in the Combat Study cohort are likely to be accounted for at least partly by the significantly lower participation rate of the transitioned group and the use of unweighted data in analyses. Furthermore, it being a highly healthy deployable cohort, lower rates might also reflect greater self-

awareness about and concern for their health and their deployability, regardless of their transition status.

The proportion of participants who had problematic anger also increased steadily from Time 1 to Time 3 (Time 1, 5.5%; Time 2, 11.6%; Time 3, 19.2%). Anger is a phenomenon of particular interest in relation to common mental disorders because it is indicative of affect dysregulation. It is likely to be an early indicator of increasing reactivity to minor provocations, as well as potentially representing emerging disorder and, although associated with all anxiety disorders and depression, it has a particularly strong association with PTSD (Olatunji et al., 2010). Anger and anxiety are linked as being defensive reactions to threat marked by activation of the sympathetic nervous system (Lang et al., 1998). Anger and fear represent the opposite ends of the spectrum in the fight-and-flight response. In the military context, in which individuals are trying to suppress their fear, emerging difficulties with anger regulation are indicative of a significant risk of behavioural disinhibition. In a combat environment this can lead to excessive reactivity to threat and could even represent a risk that an individual might not adhere to the rules of engagement.

9.5   Diagnosable mental disorder

The findings regarding symptomatic distress on the self-report measures are further elucidated by the results of CIDI interviews, which characterised diagnosable mental disorder in the Combat Study population. Overall, consistent with findings from the *Mental Health Prevalence Report* (Van Hooff et al., 2018), members of the cohort who had transitioned reported higher lifetime and 12-month rates of each ICD-10 mental disorder class compared with those who remained in the Regular ADF. Almost 80% of the cohort who had transitioned by 2015 met criteria for any lifetime ICD-10 mental disorder; this compares with two-thirds (66.7%) of those who remained in the Regular ADF. The 12-month rate for any ICD 10 disorder was 50% in the Transitioned ADF and 21.9% in the 2015 Regular ADF. This again highlights that the burden of disorder increases among those who have discharged; cohort members who remained in service had disorder rates similar to those observed in the 2010 ADF Mental Health Prevalence and Wellbeing Study (22%) (McFarlane et al., 2011b).

Anxiety disorders were the most prevalent disorder category in the Combat Study population, again consistent with findings from the broader *Mental Health Prevalence Report* (Van Hooff et al., 2018). In relation to specific mental disorders, the most common 12-month anxiety disorder type in members of the cohort who had transitioned was PTSD (22.2%); this was followed by panic attacks (15.3%) and agoraphobia (12.5%). A slightly different pattern was observed among cohort members who remained in the Regular ADF, with panic attacks (10.5%) the most common 12-month anxiety disorder in this group, followed by PTSD (7.0%). Notably, the rates of

PTSD were higher on the CIDI than observed for the self-report measures: the CIDI captures instances of disorder over 12 months, while the self-report measures reflect disorder in the preceding month only.

The findings for rates of diagnosable anxiety disorders, and PTSD in particular, characterise the burden of psychological morbidity that arises as a consequence of combat-related deployments. When considered together with the self-report symptom findings, they further underscore the delayed onset of many mental disorders, as well as the crucial importance of following the combat-exposed population over time to optimally detect the emergence of this morbidity. A series of studies have followed cohorts that have served in the Middle East Area of Operations, and they all demonstrate a pattern of increasing PTSD morbidity with the passage of time. For example, Vasterling et al. (2016) followed a cohort of 598 US Marines and found that rates of PTSD increased from 7.4% at a pre-deployment measurement to 24.7% at long-term follow-up (approximately eight years after the index deployment). Similarly, a longitudinal follow-up study of a cohort of Dutch combat troops identified an increase in the levels of symptomatic distress over a five-year follow-up period (Eekhout et al., 2016).

When considering other disorder classes and disorders, the most common 12-month affective disorder in the Combat Study cohort was depressive episodes (Transitioned ADF, 9.7%; 2015 Regular ADF, 4.4%); this was followed by bipolar affective disorder (Transitioned ADF, 8.3%; 2015 Regular ADF, 2.6%). Again, the rates were similar to those presented in the *Mental Health Prevalence Report* (Van Hooff et al., 2018). In general, alcohol disorders were not highly prevalent in this population: the most common 12-month alcohol disorder class was alcohol dependence, this being reported by 9.7% of the Transitioned ADF and a substantially smaller 3.5% of the 2015 Regular ADF. The pattern of increased alcohol consumption among Transitioned ADF members was also observed in the *Mental Health Prevalence Report* (Van Hooff et al., 2018).

The 2010 Mental Health Prevalence and Wellbeing Study also documented extremely low rates of alcohol use disorders among Regular ADF members – lower, in fact, than in the general Australian community (McFarlane et al., 2011b). It is thought that the structure and discipline of the military environment probably assist in modulating alcohol use and that this beneficial impact is then lost as the individual transitions from active service to the civilian environment. The increased levels of alcohol dependence observed among Transitioned ADF members could also suggest the use of alcohol to self-medicate because of members' higher levels of disorder. Alcohol has been shown to attenuate symptoms of hypervigilance and an exaggerated startle response (Davis et al., 2013). In a number of settings changing patterns of alcohol consumption have also been shown to be a marker for risk of PTSD (Crum et al., 2013; Kline et al., 2014).

Together, the patterns of change in mental health over time, as well as 12-month diagnosable mental disorder, indicate that, overall, members of the Impact of Combat Study cohort are psychologically healthy, reporting low rates of mental disorder in the preceding month and similar rates of 12-month disorder among the transitioned subset. This is consistent with a healthy worker effect and, in the case of 30-day probable disorder, it appears that the healthy worker effect might extend somewhat into the transitioned subset of the cohort. When considering mental health symptoms more generally, however, overall there was a general decline in the mental health of the cohort, consistent with a process of time-dependent sensitisation.

9.6 Physical health

As with their mental health, the physical health of the Combat Study cohort also declined with the passage of time, in particular reflecting non-specific somatic distress. There were increasing complaints of non-specific physical health symptoms: the number of symptoms reported nearly doubled between Time 1 and Time 3. Pain was measured only at Time 3, but the results are consistent with the increasing physical symptom burden across time in the cohort, especially among those who transitioned. A substantially greater proportion of members who had transitioned at Time 3 (9.7%) reported the highest grade of pain intensity and disability (Grade IV) compared with only 5.9% of members who remained in the Regular ADF.

The question of how the somatic diathesis of distress should be conceptualised is an ongoing challenge to medicine. The non-specific nature of physical symptoms and general pain means that they are part of the presentation of many physical disorders, as well as ageing and related degenerative disorders (McFarlane et al., 2008), creating great difficulty in determining the symptoms' origins. While medicine has competing conceptual models for the pathophysiology of these symptoms, they are major determinants of patients' perceptions of ill-health for which they seek help from medical services (Khan et al., 2003; McFarlane et al., 1994). Symptom attributional style is also one of the factors that can influence health service use (Wright et al., 2018), although this characteristic was not investigated in this study. In fact, the diagnostic category 'symptoms, signs, and other ill-defined conditions' is the most common reason for consultation in the US military (Armed Forces Health Surveillance Center, 2013). This highlights the importance of documenting the prevalence of such complaints and developing methods of understanding and managing these manifestations of distress, including what flags this presentation may trigger in the healthcare system.

In relation to the more objective measure of body mass index, over 50% of participants fell within the pre-obese range at Time 1; the proportion increased to almost 60% at Time 2 and was higher still at Time 3 (66.3%). Obesity is associated with many other

physical health problems – among them cardiovascular disease, diabetes, a range of cancers, and arthritis (Australian Institute of Health and Welfare, 2002). This also requires consideration against the background rates of PTSD in the study population. Metabolic syndrome and obesity are well-documented complications of PTSD (Perkonigg et al., 2009). Also known as insulin resistance syndrome, metabolic syndrome is a complex disorder characterised by a cluster of cardiovascular risk factors, including abdominal obesity, high blood pressure, dyslipidaemia and high levels of fasting blood glucose. The syndrome has been examined in various studies, and individuals with PTSD have been found to be at greater risk (Bartoli et al., 2013). One study found a 38.7% prevalence of metabolic syndrome in middle-aged individuals with PTSD (Rosenfeld & Ford, 2010). The relationship with PTSD was further highlighted in a longitudinal study of US veterans, which concluded that those with PTSD and depression were at greatest risk of being either obese without weight loss or overweight or obese and continuing to gain weight (Maguen et al., 2013).

As part of the Impact of Combat Study, a range of biological markers were also assessed for a limited subset of the cohort. These included measures of liver function, metabolic function and blood glucose, as well as inflammatory markers. There is now a large body of literature demonstrating the utility of measures of low-level inflammation in contributing to the prediction of long-term health outcomes – particularly in relation to chronic conditions such as diabetes and cardiovascular and metabolic conditions (Raison & Miller, 2011; Renoir et al., 2013). There is also a rapidly emerging field of neuro-immunology, which has found evidence of associations between low-level inflammation and psychological symptoms, with evidence of bi-directional effects (Raison & Miller, 2011; Rohleder & Karl, 2006; Zannas & West, 2014).

Most recent studies examining inflammation in healthy adult populations use high-sensitivity assays, with limits of detection for IL-6, for example, below 1 pg/ml (for example, see O'Donovan et al., 2012). Of relevance, 'high' circulating inflammation in this case is categorised as anything ranging from >2 pg/ml to >4 pg/ml. Preliminary detailed investigations of inflammatory markers in the MEAO Prospective Study demonstrated that inflammation was non-detectable in a number of the assays, reflecting the exceptionally healthy nature of the cohort. In the Impact of Combat Study, however, more sensitive techniques were available and allowed for the examination of much lower levels (within the normal healthy range) to be documented. This is important given the research linking consistent but only modestly elevated inflammatory cytokines (well within the normal range) with depressive and other symptoms (Raison & Miller, 2011). Low-level circulating inflammation has been found to be associated with psychological symptoms in some groups but not others, suggesting the possibility of pre-existing vulnerabilities. Despite this non-uniform concurrent association, though, the presence of only mildly elevated cytokines at

baseline does reliably predict risk for disorder development 10 or more years later for a range of conditions, among them depression, cardiovascular disease and diabetes (Pasco et al., 2010; Raison & Miller, 2011; Renoir et al., 2013; Valkanova et al., 2013). In the Impact of Combat Study, therefore, a key aim was to explore the association of baseline inflammation with possible recruitment of physical and psychological symptoms over time.

In general, the study found that biological outcomes were well within the normal ranges for a healthy population. This was expected: not only was the cohort relatively young but members were exceptionally healthy at the time of recruitment into the study. Furthermore, only small changes were observed in the biological outcomes measured, and for a number of markers no changes were found, although there were some consistent patterns of change among groups of measures. In connection with the discussion about metabolic syndrome, all the metabolic indices remained relatively stable over time, with only very small increases and decreases. This is consistent with the cohort remaining relatively healthy at the Time 3 follow-up and is to be expected given their age and the high levels of physical fitness in the cohort at baseline.

As noted, metabolic syndrome has been found to be associated with PTSD, although, importantly, the direction of this association remains unclear (Rosenbaum et al., 2015; Wolf et al., 2016). Metabolic syndrome was not directly examined in the present study, but it is of relevance to this cohort – in particular, in relation to emergence as the cohort ages. If the patterns across various outcomes observed in this study continue, increased rates of diagnosable mental disorder would be expected to emerge into the future, and it is also possible that, along with this, further physical symptoms and comorbidities could emerge. Finally, the analyses presented here pertained to the entire cohort. As discussed later, preliminary subgroup analyses suggest that any further detailed analyses of the data should consider subgroups that might be particularly at risk.

Although the more general biological indicators showed very little change over time, changes were documented for the inflammatory markers. The measures of acute infection and inflammatory response showed little movement – again in keeping with the cohort being relatively healthy at each time point – but for the pro-inflammatory markers (IL-6, TNF alpha, CRP and cortisol) there was a trend towards increasing levels at Time 2 and a decrease at Time 3. This pattern is in keeping with what might be expected from an adaptive immune response to stress (Dhabhar, 2014; Lovallo, 2015), whereby the HPA axis mounts an immune response to the stressor (in this case deployment) that reduces once the stressor has passed, returning the system to homeostasis (McEwen, 1998; McEwen, 2000). This finding not only indicates that in general while the experience of deployment may lead to shifts in physiological

indicators of stress, these changes are not sustained long term, but also that there may be practical utility in documenting shifts in immune response in relation to stress.

Together, these physical health symptoms and biological markers are an important domain to document and monitor over time, especially because of the importance of managing the emergence of mortality in the study population. At a cohort level there does not appear to be evidence of systemic dysregulation in physiological stress response systems, but in the light of the observed shifts in psychological and somatic symptoms over time it is possible that shifts in physiological systems, and the development of physical conditions, could emerge with the passage of further time. There is some evidence that the relationship between psychological distress and shifts in the physiological stress regulation system is bi-directional (Renoir et al., 2013), so with the further recruitment of symptoms over time it is possible that biological systemic dysregulation could emerge.

9.7   Predicting mental health over time

In addition to the longitudinal course of mental, physical and biological health indices over time, the contribution of various factors to mental health at Time 3 was explored. Results of multivariate predictive modelling showed differential patterns of predictors for psychological distress and posttraumatic stress over time.

Deployment experience at Time 1 and number of combat exposures experienced during a responder's military career were significant predictors of elevated psychological distress at Time 3. In contrast, the strongest predictors of elevated posttraumatic stress symptoms at Time 3 were lifetime traumatic events and the number of traumatic deployment exposures experienced during the responder's career. This suggests there might be more trauma-specific effects for PTSD, while other factors have additional impacts on the development of psychological distress over time. As is discussed later in this chapter, corresponding evidence to support this was also found in a descriptive analysis of objective neurocognitive markers in participants with and without elevated psychological distress or posttraumatic stress symptoms at Time 3.

Given that psychological distress is by its nature a more general response, this difference is perhaps not surprising. Importantly, in both models the contribution of deployment trauma to subsequent psychological symptoms is clear, and it appears there is a dose–response association, with a threshold at which the effects of exposure begin to emerge. Exposure measures are captured routinely in post-operation psychological screening, which provides an opportunity to monitor the dose, noting that the risk appears to be cumulative across the career rather than just for a single deployment. Furthermore, the finding of the significant univariate predictive power of

low-level posttraumatic stress and psychological distress symptoms following deployment (at Time 2) is important. The vast majority of cohort members were below screening cut-offs on these measures at Time 2, so would not have been identified as at risk during post-operation psychological screening. This suggests that scoring above the recommended screening cut-off might not be optimal in terms of sensitivity for detecting individuals at risk of disorder emerging later.

In addition to this predictive modelling, some limited descriptive analyses examining the patterns of physical health indices over time among participants with and without elevated psychological distress or posttraumatic stress symptoms at Time 3 were performed. Self-reported physical health symptoms and key inflammatory markers were examined. Although preliminary and descriptive in nature, the results were somewhat consistent with the findings observed for psychological symptoms insofar as groups exhibiting elevated psychological symptoms at Time 3 had differential physical health symptom patterns over time and exhibited a distinct pattern of inflammatory marker levels over time.

At all three time points the number of physical health symptoms reported was higher among subgroups with elevated psychological distress or posttraumatic stress symptoms at Time 3. Furthermore, the difference in symptom numbers between symptomatic and healthy subgroups became larger over time. Consistent with a sensitisation model (Boscarino, 2006; McEwen, 1998, 2000), it appears that the progressive recruitment of symptoms is particularly occurring among those with increasing manifestation of distress over time. There are very subtle shifts in symptoms among the healthy subgroup, with a trend towards increases, yet this was markedly less than for those with distress.

To further elucidate these findings, detailed analysis of the differences in lifetime and deployment exposure profiles between these groups should be done. It is possible that those with the greatest distress at Time 3 and who show this pattern of increasing symptom emergence are also those who have the highest levels of exposure initially at Time 1. If this is the case, it presents another compelling argument for continued surveillance of the cohort in the long term, affording an opportunity to identify the emergence of initial dysregulation.

In the case of inflammatory markers, in the subgroups with elevated psychological distress or posttraumatic stress symptoms in general, with the exception of C-reactive protein and cortisol, all markers were lower at Time 1 and remained lower at all three time points than was the case for the healthy subgroup; CRP showed a slightly different pattern, increasing over time in the symptomatic subgroups; cortisol was elevated in the symptomatic subgroups, although the difference dissipated over time. Together, these findings are indicative of a general down-regulation of the immune

response (Cohen et al., 2012; Phillips et al., 2010) among a subgroup of the combat cohort who are experiencing symptomatic distress at Time 3. Having relatively higher levels of immune stress markers at pre-deployment (as seen in the Time 3 healthy subgroups) could indicate a stress responsivity system that is primed and prepared (Huang et al., 2010). Since the pre-deployment period is likely to be physically and mentally stressful, higher levels of these markers at this point could be expected. Regular physical activity has been found to be associated with less systemic low-grade inflammation, despite triggering inflammatory peaks (as seen here in the healthy subgroup) (Phillips et al., 2010). Low levels of inflammatory markers, as observed in the symptomatic subgroup, are suggestive of an under-reactive or dysfunctional immune response system. Although lower levels of inflammation might seem counter-intuitive, they could in fact represent an adaptation to a hyper-reactive stress response system (Phillips et al., 2010); that is, a system that is hyper-reactive to stressors (sensitised) might adaptively down-regulate.

In relation to the low-level increase in CRP over time in the symptomatic group, Eraly et al. (2014) found that the level of CRP at pre-deployment predicted later emergence of PTSD symptoms among US Defence Force personnel. Inflammation was most strongly related to hyperarousal and numbing symptoms, and the results showed that, rather than an incremental effect, inflammation predicted the presence or absence of symptoms. The results also suggested that inflammation might increase the risk of developing symptoms, with other factors influencing disorder severity.

More generally, existing research has begun to map the association between systemic and/or acute inflammation and both physical and psychological health outcomes concurrently and over time. A large body of literature suggests that subclinical levels of a range of inflammatory markers are associated with the occurrence and development of various physical health conditions and psychological disorders (Renoir et al., 2013). There is also some suggestion that patterns of inflammation might be associated with poor health trajectories in general – in this way representing 'risk' markers. Research has demonstrated that inflammation (as measured by various pro-inflammatory mediators such as the interleukins and CRP) is prospectively associated with PTSD development (Eraly et al., 2014; Gill et al., 2014) and depressive disorders (Gill et al., 2014; Loftis et al., 2010; Walker et al., 2014). In the case of psychological disorders, the role inflammation might play in their aetiology is still not clearly understood, although there is evidence that the presence of inflammatory cytokines in the brain is associated with impaired cognitive function and disruptions to the secretion of various neurotransmitters (Eraly et al., 2014). In terms of the possible processes underlying the relationship with PTSD in particular, noradrenergic dysregulation has been implicated in a number of psychological conditions, including PTSD (Krystal & Neumeister, 2009), and is most clearly associated with hyperarousal symptoms. Increased levels of noradrenaline should be associated with reductions in inflammatory cytokines, but rat

models have shown that in the case of metabolic syndrome there is a dysregulation in the feedback mechanism between IL-6 and noradrenaline, meaning that inflammatory cytokines remain elevated despite the release of noradrenaline. It is conceivable that subclinically elevated cytokines could represent noradrenergic dysfunction, which then increases PTSD risk following stress exposure. Noradrenergic dysfunction could thus constitute a risk factor for development of psychopathology following stress exposure.

There is a need for further work, with more targeted subgroup analyses, to explore the within-group changes and between-group differences observed in the descriptive analyses discussed here. In particular, examination of markers in individuals with no, subsyndromal and probable disorder would be useful, as would be a focused investigation of these markers in individuals who met diagnosable disorder status on the CIDI in 2015. Additionally, there is evidence of long-term effects of low-level elevations in CRP on physical health outcomes (Cushman et al., 2005; Kuo et al., 2005; Suleiman et al., 2006), with increased risk of cardiovascular disease and mortality 10 years later; following this cohort up longitudinally is therefore of great importance.

9.8 Neurocognitive findings

As well as the range of self-reported measures of mental and physical health and functioning and the biological measures, neurocognitive data were collected on this cohort, representing an additional objective marker of functioning – in this case cognitive. These findings provide important insights into the hyperarousal that veterans commonly report following deployment. Importantly, the shifts in arousal are observable by an objective methodology that does not depend on self-reported data. Although the findings reported here are technical, they do offer evidence about how neurophysiological assessments can be used to provide valuable information about the effects of deployment. The significance and meaning of these findings should be considered as a preliminary exploration of these phenomena: similar research has not previously been conducted in non-clinical samples in the context of such major stress exposures.

9.8.1 Quantitative electroencephalography

The overall pattern of qEEG findings in this study suggests that initial deployment and combat exposure can have lasting impacts on resting cognitive states. Although a number of consistent trends were observed in all groups over time (as discussed shortly), when considering individuals with elevated psychological distress or posttraumatic stress and those who remained healthy at Time 3, groups exhibited numerous distinct qEEG characteristics that have the potential to prove useful in the prediction and monitoring of long-term mental health trajectories.

In the beta power band, where increased activity is associated with cortical excitability, all groups exhibited reduction trends at Time 2, indicating a ubiquitous acute impact of deployment on fast-wave brain activity. This could reflect decreased arousal post-deployment, in contrast to anticipatory arousal observed before deployment. All groups also subsequently exhibited evidence of beta power increases between Times 2 and 3, indicative of a progressive increase in cortical excitability, which is consistent with a trend towards recovery over time. Importantly, in all groups sustained reductions remained evident at Time 3, although these were greatest in those with elevated psychological symptoms at Time 3. This is consistent with long-term resetting of the cortical metabolism and is evidence of an enduring general long-term effect of deployment on fast-wave brain activity, even in non-symptomatic groups. This could represent one biological signature of the cumulative effects of deployment and trauma exposure that is not directly indicative of disorder.

Interestingly, among those with psychological distress there appeared to be a progressive transition from lower beta power at Time 1 to higher power levels at Time 3. This increased beta power in those with psychological distress might be acquired progressively and potentially in conjunction with depression/anxiety symptom development. Among individuals with elevated posttraumatic stress symptoms a different pattern was apparent. There was an opposite beta power change over time when compared with the healthy subgroup: beta power was higher at Time 1, decreased between Time 1 and Time 2, and then increased between Time 2 and Time 3. It thus appears that higher pre-existing beta power might be associated with eventual PTSD symptom development, whereas lower pre-existing beta power might be associated with more favourable long-term mental health outcomes. Since there is some contention about the notion that anxiety disorders might precede the eventual development of PTSD (Goodwin et al., 2004; Marshall-Berenz et al., 2011), it is possible that the elevated beta power at Time 1 was an indicator of anxiety symptoms (as discussed in relation to psychological distress). The findings show that reduced beta power was apparent in individuals who developed PTSD symptoms in the immediate post-deployment period but that this was only a temporary shift and was consistent with the low level of symptoms in this group, which increased with the passage of time.

The patterns of elevated beta power observed in both psychopathology groups are notably consistent with previous cross-sectional research demonstrating higher beta power in clinically diagnosed PTSD and depression/anxiety disorder groups (Begić et al., 2001, 2011; Jokić-Begić et al., 2003; Knott et al., 2001; Pollock & Schneider, 1990; Sachs et al., 2004a). The current prospective findings thus extend previous cross-sectional research by providing evidence of acquired beta power elevations in military groups who develop depression/anxiety symptoms and pre-existing beta power elevations in military groups who develop PTSD symptoms.

In the alpha power band, all groups exhibited similar reductions (Time 1 to Time 2) and partial recovery (at Time 3) trends. Interestingly, however, those with elevated posttraumatic stress symptoms exhibited progressive/sustained anterior increase trends, which contrasted with the broadly similar reduction trends that were observed in the other groups. Occipital activity is reflective of arousal level (Barry & De Blasio, 2017; Cantero et al., 1999), so the changed distribution observed in this study is suggestive of psychopathology. While alpha power reduction trends in those with elevated psychological distress were notably similar to those in the healthy subgroup, examination of power disparities revealed lower alpha power levels in those with psychological distress at all time points. It thus appears that lower pre-existing alpha power might be associated with eventual depression/anxiety symptom development. Interestingly, while those with elevated posttraumatic stress symptoms exhibited somewhat lower alpha power levels than the healthy subgroup at Time 1, these relative differences were not as pronounced as those observed in the group with psychological distress. Furthermore, in stark contrast with participants with elevated psychological distress, alpha power levels among those with elevated posttraumatic stress symptoms at Times 2 and 3 were shown to be higher than in the healthy subgroup. These disparities at Times 2 and 3 appeared to be predominantly attributable to within-group reduction trends in the healthy subgroup. As a result, alpha power disparities in those with elevated posttraumatic stress symptoms do not appear to bear a consistent association with eventual PTSD symptom development.

Alpha power reductions observed among individuals with elevated psychological distress are notably consistent with previous cross-sectional research by Begić et al. (2011) demonstrating reduced alpha power in individuals with clinically diagnosed depression. This finding is, however, somewhat at odds with other cross-sectional research demonstrating alpha power increases in depression and anxiety disorder groups (Knott et al., 1996; Pollock & Schneider, 1990). Similarly, while relatively lower power levels at Time 1 among those with elevated posttraumatic stress bear some consistency with research demonstrating alpha power reductions in clinical PTSD (Jokić-Begić et al., 2003; Veltmeyer et al., 2006), relative increases at Times 2 and 3 are again at odds with these reports. Notably, since the groups with elevated posttraumatic stress and psychological distress exhibited considerable symptom crossover, inconsistencies with previous research might be attributable to comorbidity dynamics in these groups (that is, the relative predominance of depression, anxiety or PTSD symptoms in those exhibiting high comorbidity). The current findings warrant further investigation to elucidate more precise alpha power associations with specific symptom profiles.

In the case of the theta power band, all groups exhibited only marginal power changes between Time 1 and Time 2, suggesting that deployment does not have a robust acute impact on slow-wave brain activity. Most interestingly, however, in contrast with

stable trends between Time 2 and Time 3 in the healthy subgroup, those with elevated psychological distress or posttraumatic stress symptoms exhibited robust increases (above their respective Time 1 levels). Thus, while effects of deployment were only marginal overall, symptomatic groups appeared to be characterised by pronounced subsequent theta power increases, which were not evident in the healthy subgroup. Furthermore, they appear to also have higher theta power at Time 1 and Time 2. It is thus possible that higher pre-existing theta power could be associated with eventual PTSD or depression/anxiety symptom development and that progressively more pronounced increases in slow-wave brain activity might also develop in conjunction with, or subsequent to, eventual psychological symptom development.

Although there are some exceptions (Sachs et al., 2004a, 2004b; Veltmeyer et al., 2006), patterns of elevated theta power in these psychopathology groups appear highly consistent with previous cross-sectional research demonstrating higher theta in clinically diagnosed PTSD (Begic et al., 2001) and depression/anxiety disorder groups (Begić et al., 2011; Knott et al., 1996; Nystrom et al., 1986). Frontal theta has also been found to correlate with anxiety scores (Kropotov, 2008). The current prospective findings thus extend previous cross-sectional research by providing evidence of both pre-existing and acquired theta power elevations in military groups who develop PTSD and depression/anxiety symptoms.

Taken together, the findings from the present study suggest that individuals who manifest psychological symptoms over time exhibit a range of distinct qEEG characteristics. In particular, beta and theta power bands appear to bear the closest association with current psychological symptom status at Time 3. Higher beta and theta power levels at Time 1 also appear to potentially be vulnerability factors for the prediction of future symptom status at Time 3, while alpha power might be more closely associated with the actual symptom profile.

9.8.2   Working memory

As discussed in the introduction to this report, working memory is of particular interest in military populations because military-specific factors such as deployment have been found to be associated with deficits in a variety of areas of cognitive functioning and have the potential to disrupt information processing (Johnson et al., 2013). Disturbances in cognitive function are also associated with a range of psychiatric disorders that tend to be prevalent in military populations – among them depression, panic disorder, generalised anxiety disorder and PTSD (Castaneda et al., 2008; Rose & Ebmeier, 2006) – and may also be compromised in people who have suffered a mild traumatic brain injury (Lagarde et al., 2014).

In this study working memory was assessed using ERP (event-related potential) data. The P3 amplitude was used, providing an objective surrogate measure of working

memory functioning that is derived from brain registration of target stimuli that must be detected and responded to. The amplitude of the P3 is an indicator of the efficiency of processing, greater amplitude reflecting greater efficiency, so when working memory efficiency is discussed this refers to changes or differences in P3 amplitude. It should also be noted that, although ERP data were used as a measure of working memory in the study, no corresponding neuropsychological assessments of working memory were included. While there were some overall trends in the population, the symptomatic and healthy subgroups exhibited a number of patterns of working memory efficiency that could possibly prove useful in the prediction and monitoring of long-term mental health trajectories.

Examination of within-group change trends from Time 1 to 2 revealed pronounced decreases in working memory efficiency in the healthy subgroup. This finding is consistent with behavioural measures that demonstrate declines in working memory among combat troops post-deployment, independent of PTSD (Vasterling et al., 2006a, 2006b). Importantly, these reductions were followed by recovery trends (increases) at Time 3, suggesting a recovery in working memory function over time. The findings appear consistent with an acutely acquired (that is, deployment-related) impairment in fronto-central attention networks, followed by functional recovery over the longer term. Thus, while deployment appears to have an acutely detrimental impact on attentional network function, such impairments, if present, do not appear to be enduring among individuals who do not develop psychopathology symptoms over time. This is at variance with the findings of an fMRI study of working memory in Dutch troops, who continued to demonstrate abnormalities of dorsolateral prefrontal activity 18 months post-deployment (van Wingen et al., 2012). In the present study, somewhat similar trends were evident at the parietal electrode, with parietal amplitude changes observed but of a lesser magnitude. It thus appears that more posterior executive memory network functions remain relatively unchanged among individuals who remain asymptomatic.

Better working memory function at Time 1 appeared to be a particular marker of positive long-term mental health trajectories. The effects of military deployment on ERP indices have not been widely examined, but these findings are highly consistent with previous neuropsychological evidence of symptom-independent attentional deficits in recently deployed military personnel (Vasterling et al., 2006a, 2006b).

In contrast with trends observed in the healthy subgroup, study participants with elevated psychological distress had lower working memory efficiency at Time 1 and exhibited robust increases in attentional processing between Times 1 and 2. These elevations were, however, followed by a decrease at Time 3. Although speculative, the findings appear to suggest an acute deployment-related acquisition of attentional vigilance to target detection in this group, followed by subsequent regression towards

pre-existing attentional network function. Thus, while deployment appears to have a robust impact on attentional network function in those who develop depression/anxiety symptoms, these acute effects are not long-lasting. Similar trends were evident at central and parietal electrodes, but these amplitude changes were of a lower magnitude, highlighting the importance of the frontal executive networks in these changes.

The finding of poorer working memory efficiency at Time 1 in the subgroup with psychological distress is consistent with findings from a study of active-duty US personnel, showing that neuropsychological changes observed in those with depressive symptoms appeared to be a marker of a pre-existing working memory deficit rather than an indicator of the effects of deployment (Marx et al., 2009). This suggests that pre-existing attentional network impairments, as indexed by lower fronto-central amplitudes, could be a vulnerability marker for future depression/anxiety symptom development. There is also a more general literature indicating that cognitive factors are a risk factor for depression (Paradiso et al., 2011) and co-occur with clinical depression – see Luck & Kappenman (2011) for a review. Importantly, the current findings extend this previous research by providing evidence that working memory deficits might pre-exist symptom onset. These deficits are consistent with those seen in some anxiety disorder groups (Berryman et al., 2017; Sachs et al., 2004a, 2004b) but they are at odds with reports of amplitude elevations observed in panic disorder (Clark et al., 1996; Iwanami et al., 1997).

Like the healthy subgroup, participants with elevated posttraumatic stress symptoms exhibited working memory deficits between Times 1 and 2. In contrast with the healthy subgroup, though, these deficits were followed by pronounced additional decrements in function at Time 3. These findings thus suggest acutely acquired (that is, deployment-related) attentional network impairments followed by a progressive exacerbation of these impairments over the longer term. Interestingly, while only minimal deployment-related reductions were evident at central and parietal electrodes, more pronounced amplitude decrements became evident at Time 3 (albeit to a lesser extent than those observed frontally). Therefore, although deployment appears to predominantly affect anterior attentional network functions, it seems that there could be progressive impacts on posterior executive memory network functions in the longer term.

Lower amplitudes at Time 3 among participants with elevated posttraumatic stress symptoms are consistent with previous cross-sectional research demonstrating reduced P3 amplitudes in clinically diagnosed PTSD groups – see Johnson et al. (2013) for a review. The current findings extend this previous research by providing evidence that fronto-central amplitude reductions might pre-exist PTSD symptom onset. As noted, however, individuals who go on to develop PTSD have already had significantly

higher cumulative trauma exposures and some early signs of symptom development. Interestingly, the observation that parietal amplitude reductions were evident only at Time 3 is highly consistent with previous monozygotic twin research indicating that parietal (P3b) amplitude reductions are an acquired characteristic in PTSD (Metzger et al., 2009). The P3 findings might therefore serve as a marker of emerging subsyndromal distress in this population (McFarlane et al., 2017).

Finally, the frontal and central amplitudes among individuals with elevated psychological distress were shown to be lower than those among the healthy subgroup at all time points, with the parietal amplitudes also relatively reduced at Time 3. It is possible that pre-existing attentional network impairments, as indexed by lower fronto-central amplitudes, reflect a vulnerability marker for future PTSD symptom development, whereas executive memory impairments, as indexed by parietal amplitude reductions, might develop in conjunction with or subsequent to development of symptoms of psychological distress.

The findings for general cognitive and working memory function are consistent with the results of previous cross-sectional research, although it should be stressed that small sample sizes precluded statistical significance testing in the present investigation. These descriptive findings are therefore preliminary and should be interpreted with caution. Nonetheless, the prospective design of this study represents an important step towards identifying objective neural markers that could assist in the prediction and monitoring of long-term mental health trajectories in the military context.

These findings extend the earlier conclusions of the MEAO Prospective Study report (Davy et al., 2012) and demonstrate the long-term shifts in arousal that accumulate following deployment. Davy et al. highlighted the role of antecedent deployments on cortical arousability. The present study demonstrates the enduring consequence of that shift, and that the passage of time, for those who become symptomatic particularly, is associated with further escalations of these abnormalities. The present findings also suggest that military deployment has an acutely altering effect on functioning in the brain's fronto-central attentional orientation networks, with evidence of functional decrements in the healthy subgroup and those with elevated posttraumatic stress symptoms and attentional hypervigilance among individuals with elevated psychological distress. These acute deployment-related effects appear to resolve in the healthy subgroup and those with psychological distress. In contrast, acquired functional decrements appear to be progressively exacerbated in individuals with elevated posttraumatic stress, with executive memory network impairments also becoming evident over the long-term. Perhaps most crucially, the current findings also suggest that individuals with psychopathology at Time 3 exhibit relatively diminished fronto-central amplitudes at Time 1. It is thus possible that functional impairments

across fronto-central attentional orientation networks reflect a pre-existing marker of vulnerability for future psychopathology symptom development.

Although the current findings are highly consistent with the results of previous cross-sectional research, it should be stressed that small sample sizes precluded statistical significance testing. These preliminary findings are thus descriptive and should be interpreted with caution. Nonetheless, the prospective design of the current investigation represents a crucial step towards identifying objective neural markers that might assist in the prediction and monitoring of long-term mental health trajectories in the military context. Further investigation in a larger military population appears warranted. Finally, the findings suggest that the measure of working memory by event-related potential has utility as an objective measure of potential risk factors and emerging correlates of mental disorders in combat troops.

9.9   Traumatic brain injury

As part of the broader Impact of Combat Study a focused cross-sectional analysis of traumatic brain injury was undertaken, including self-reported prevalence and correlates, as well as a pilot neuroimaging investigation.

9.9.1   Injuries to the head and TBI

Self-reported injuries to the head were assessed as part of the Ohio State University TBI inventory (Corrigan & Bogner, 2007). Self-reported lifetime TBI was also captured in this measure and was classified according to one of six categories ranging from no TBI to severe TBI. The assessment of head injury and TBI used an instrument that has been used in overseas studies of military populations (Schwab et al., 2017), although a limitation is that the assessment is based on self-reporting, rather than a documented head injury or loss of consciousness, and refers to an event that possibly occurred several years before. Recall bias could be a factor that influences the accurate recall of a head injury. This is recognised as a problem inherent in the study of TBI and mTBI.

When considering the findings from this study it is important to note that only a very small proportion of both Transitioned ADF members and 2015 Regular ADF members reported either moderate or severe TBI (3.8% and 2.9% respectively), while the great majority of reported lifetime TBI was mTBI. Approximately 40% of both Transitioned ADF and 2015 Regular ADF were classified as reporting no lifetime TBI or a head injury without loss of consciousness or being dazed or confused. A group who reported head injuries with no loss of consciousness but who were dazed or confused were classified as having probable mTBI. This classification is consistent with how the measure is used, but it is important to note that they should be considered probable. In the case of a self-reported head injury without loss of consciousness, being dazed and confused could reflect emotional or physical shock after the event rather than a TBI. The

proportions of reported lifetime moderate and severe TBI were too small for specific comparisons and so were combined with the much larger mTBI categories in a dichotomised TBI variable for further analyses. The dichotomised TBI variable therefore consisted predominantly of participants with mTBI (including those with no loss of consciousness but who were dazed or confused) but also included some with moderate or severe TBI. Because severe TBI is likely to have occurred in the context of multiple traumas, this should be considered in the interpretation of findings.

For both groups the most commonly reported context for experiencing a head injury in their lifetime was being nearby when an explosion or blast occurred, which is consistent with the most frequently cited mechanism of injury in overseas studies (Hayward, 2008). In the present study a greater proportion of Transitioned ADF members compared with 2015 Regular ADF members reported a head injury relating to explosion or blast. Possible explanations for this could relate to the military characteristics of the Transitioned ADF members or the possibility of increased occurrence during training.

The proportion who were classified as having a lifetime mTBI with loss of consciousness for less than 30 minutes was 19.4% in Transitioned ADF and 29.2% in 2015 Regular ADF; a slightly greater proportion of 2015 Regular ADF reported no TBI compared with Transitioned ADF. 2015 Regular ADF reported a higher mean number of lifetime TBIs than Transitioned ADF. Comparisons of mTBI prevalence with other studies are difficult because of differences in the definitions used. The reported lifetime mTBI prevalence in the MEAO Prospective Study was 26.9% (Davy et al., 2012) and, although the definition is not identical to that used at this third time point, the relatively similar rates in the Regular ADF, with a very small increase, suggest little change over time (although change over time was not specifically examined in these analyses).

The raw prevalence of probable lifetime TBI in the current study is higher than that reported in studies of US (Hoge et al., 2008; Rona et al., 2012a; Wilk et al., 2012) or Canadian (Garber et al., 2016) military populations, although the current study reported lifetime TBI prevalence rather than deployment-specific TBI. Schwab et al. (2017) found that 9.5% and 7.9% of soldiers returning to two US bases from Iraq and Afghanistan between 2009 and 2014 screened positive for probable mTBI using the definition and instrument used for the present study. This was, however, in relation to the soldiers' last deployment rather than for their lifetime. An mTBI rate of 5.2% among Canadian personnel deployed to Afghanistan between 2009 and 2012 was reported by Garber et al. (2014), although the instrument used was not directly comparable. Importantly, the Garber et al. rates focused specifically on mTBI and excluded individuals with loss of consciousness greater than 20 minutes, potentially accounting for some of the difference in rates.

Transitioned ADF generally had higher posttraumatic stress symptoms, psychological distress and depressive symptoms than 2015 Regular ADF, and this pattern was similar when comparing members with reported TBI and those without in the two groups. In each of the Transitioned ADF and 2015 Regular ADF groups posttraumatic stress symptoms, psychological distress and depressive symptoms were similar between those with reported TBI and those without. Transitioned ADF, however, generally had higher reporting of these psychological symptoms than 2015 Regular ADF, including when those with reported TBI and those without were compared across the two groups – a pattern of increased reporting of psychological symptoms consistent with the *Mental Health Prevalence Report* findings (Van Hooff et al., 2018). A similar pattern was seen in relation to global functional impairment scores. It was also seen in relation to post-concussive symptoms with one exception: among Transitioned ADF, mean post-concussive symptoms were higher among those with a reported TBI compared with those with no reported TBI. Some caution is, however, required in interpreting post-concussive symptoms in the current study since these symptoms were asked about in relation to the preceding week, while the event to which they related to could have occurred many years previously.

9.9.2   The pilot neuroimaging study

With a single exception, the findings from the pilot neuroimaging study of white matter integrity in a subset of high combat and blast-exposed ADF members yielded no significant associations with psychological, neurocognitive or exposure-related indices. The exception was that, in terms of structural findings, greater self-reported exposure to blast/explosions was associated with reduced thickness of the left precentral gyrus.

Situated in the posterior section of the frontal lobe, the precentral gyrus is known as the primary motor cortex because it is a brain region implicated in motor coordination. Previous studies of sports injuries have reported a thinner precentral gyrus in people with a history of concussion when compared with people without such a history (Meier et al., 2016). A recent study of combat veterans found that, regardless of PTSD status, they had poorer connectivity between the left precentral gyrus and the caudal anterior cingulate than controls who had not experienced combat (Kennis et al., 2015). Kennis et al. suggested that the experiences of combat, including exposure to explosions, might affect the functional capacity of the precentral gyrus. It is therefore plausible that in the current sample greater exposure to blast/explosions affected the thickness of the neural structure implicated in how voluntary motor skills are coordinated. Again, though, it must be emphasised that this is a highly speculative suggestion because of the following factors.

As noted in relation to the results reported in Chapter 7, there are several important caveats to and possible methodological explanations for the lack of associations observed between many of the variables. First, correlations indicate an association and

do not suggest a causal relationship between observed factors. Second, many correlations were observed in the analyses of the data and very few passed the strict significance level. This underscores why the single significant correlation observed should be considered very cautiously: it could be a result of chance. A third factor is that the limited sample size reduces the statistical power to identify possible associations.

A fourth major limitation concerns the absence of a comparison condition. Whereas many other studies have directly compared military personnel who have sustained a TBI with those who have not, the current design did not have such a comparator. Selection of an appropriate comparison group would have been difficult in this study because there are numerous factors one could control for – for example, the presence of TBI, the level of PTSD, the level of combat exposure, and the number of exposures to explosions. It is difficult to control for all these potential confounders in identifying the ideal comparison condition.

A fifth factor that needs to be considered is that a significant proportion of the current sample were Special Forces personnel, who are not representative of the broader ADF population. Although they are very exposed to high-risk combat situations, they are by definition highly screened and have undergone many strict selection procedures to achieve this status. Accordingly, their capacity to achieve Special Forces status and maintain this high level of functioning in the face of rigorous training and deployment demands limits the generalisability of the findings to most ADF personnel.

Finally, it needs to be understood that our assessment of TBI was based on self-reporting and was retrospective in nature. This is an inherent limitation throughout the Combat Study because definitive assessment of TBI requires objective documentation at the time of injury and, ideally, verification by proper medical assessment in the hours and days after the injury. In relation to military personnel, this should be done in in-country medical centres and the primary data should be the source from which the categorisation of TBI derives. This has been done in some studies. For example, the STRONG STAR research program in Iraq routinely assessed all personnel who were documented to have been exposed to an explosive blast (n = 685), and they were all routinely administered a full assessment for mTBI and its effect, including the Military Acute Concussion Evaluation (Bryant et al., 2015). This form of routine assessment has the potential to provide much more accurate profiling of the occurrence of mTBI, which allows for stronger inferences to be drawn from longitudinal studies of the effects of the mTBI.

As noted, the goal of the neuroimaging study was to conduct a small-scale proof-of-concept study to determine if any neural abnormalities could be detected that were associated with TBI, with exposure to explosions or with psychological symptoms. It

was not the intent of the study to provide a definitive answer to these questions. One of the reasons for not conducting a large-scale study of these factors in the current research program is that such studies are extremely costly and demanding of human resources. Each assessment – including brain scans, testing of neurocognitive functioning and psychological assessments – requires nearly a day of testing. To obtain the required statistical power and to obtain a sufficiently large sample of personnel with and without a TBI would have been extremely demanding of the resources available and a risky endeavour given the limited knowledge about the impact of ADF members' experiences on neural functioning.

One question that arises from the current study is whether substantive effort should be placed on research into neural functioning in TBI-affected personnel. Although this study produced no strong evidence of neural dysfunction associated with TBI, the current data do not permit definitive answers to this question because of the limited design and small sample size. It should be noted, however, that in the United States and Europe very large studies of troops who have deployed to the Middle East are being conducted. US personnel have been exposed to IEDs and other explosive experiences at a much higher rate than ADF personnel, and for this reason US studies are being conducted with much larger sample sizes and very large budgets. For example, programs enrolling over 1000 cases are under way, with the goal of understanding the distinctive impact of mTBI on neural structure and functioning. Typifying the sample sizes for this sort of study is a recent report on 230 military personnel who underwent MRIs to identify distinctive neural function (Blessing et al., 2018). Moreover, increasingly consortia are forming that are combining datasets to provide the optimal power to detect effects of PTSD and mTBI on neural structure. For example, the ENIGMA project has published cortical data on over 1800 participants, many of whom are from military samples; this is providing significant insights that no single study can achieve (Logue et al., 2018). These very large studies are occurring in settings with much higher rates of mTBI than in the ADF, and it is questionable whether the ADF or DVA can learn significantly more from neural studies of mTBI relative to current much larger programs of research.

9.10   General discussion

The purpose of the MEAO Prospective Study was to document the health and functioning of a healthy deploying cohort of ADF members, with the aim of documenting the change in their health with the passage of time. It was not anticipated that there would be shifts towards disease or disorder immediately post-deployment in more than a small number of personnel. Rather, the study provided an opportunity to document exposures on deployment, the subsequent onset of minor symptoms on repatriation, and how these effects of combat exposure and deployment might develop over time. The Impact of Combat Study represents the second

longitudinal follow-up of this cohort post-deployment. What the latter study has demonstrated is that the majority of cohort members remain healthy and largely asymptomatic, although this proportion is reducing over time for most health outcomes. As anticipated, rates of psychological and physical symptoms and disorder increased over time in the cohort, although the substantial majority remained below screening thresholds. Of importance, however, were the shifts in symptoms documented, with an increased proportion of the cohort scoring above screening thresholds, despite the proportion meeting criteria for probable disorder remaining low.

Overall, findings from this Impact of Combat Study are consistent with a sensitisation hypothesis, whereby symptoms emerge progressively with time. For the most part, given that this began as an exceptionally healthy cohort, this recruitment of symptoms has at most tipped members into subsyndromal disorder, with only relatively few meeting probable disorder criteria at this follow-up. The pattern of findings reported here strongly supports the need for further longitudinal surveillance of this cohort since it is likely that the trend toward recruitment of symptoms will continue for particular subgroups of individuals and further disorder will emerge in the future.

Although the majority of cohort members were healthy and remained so at this time point, the findings also demonstrate the importance of examining subgroups in the broader cohort. In the broader cohort, as well as in the nested subgroups, there were clear differences in the symptom trajectories of individuals who were more symptomatic at this time compared with those who remained relatively symptom free. In some cases the pattern of change over time was in fact opposite between the symptomatic and healthy subgroups, emphasising the importance of these subgroup examinations. Furthermore, in both predictive analyses of self-reported data and descriptive analyses of objective neurocognitive data, there was evidence of distinct trajectories for subgroups exhibiting symptoms of elevated psychological distress as opposed to posttraumatic stress.

In relation to the impacts of deployment more specifically, on both self-reported and objective measures minor degrees of distress and related biological and neural dysregulation that can be detected before deployment appear to be an indicator of risk of further dysregulation after the deployment cycle. Even relatively minor shifts at post-deployment appear to represent a substantial risk for the emergence of subsyndromal or diagnosable disorder over time. This is consistent with a pattern of sensitisation and increasing dysregulation.

In relation to the objective neurocognitive measures captured in this study, the shifts in cortical arousal and the efficiency of working memory systems appear to predate the self-report of significant levels of psychological distress and posttraumatic stress.

This suggests that abnormalities that have previously been shown to be associated with PTSD predate the diagnosable disorder and may be markers of emerging disorder or subsyndromal symptoms.

The data also suggest that there were significant differences between individuals who developed PTSD – which was more closely linked to a cumulative life experience of trauma exposure and deployment trauma – and those who had generalised psychological distress, as measured by the K10. Particularly in the case of the ERP and qEEG results, the distress/K10-positive group had more stable abnormalities across time, whereas the PTSD group demonstrated a further and continued incremental disruption of working memory function at Time 3.

It is important to emphasise that only two of the neurophysiological paradigms have been analysed to date. Within these datasets there is a significant body of other information of considerable interest. For example, on the 'fearful faces' paradigm, a report on the prospective study dataset indicated that there were characteristics that allowed some discrimination of the PTSD and the mTBI subgroups (Zuj et al., 2017). This highlights the potential usefulness of these measures for further characterising the underlying patterns of neurobiological dysregulation in this group of veterans.

In summary, for a range of measures of self-reported symptomatic distress, biological and neurocognitive functioning, it can be seen that there is a series of progressive recruitments of symptoms and distress with the passage of time in the context of progressive neurobiological dysregulation. The pattern for posttraumatic stress symptoms appears to be significantly different from that for the distress characterised by the K10. In the PTSD group the effects of higher cumulative trauma exposure and recent deployment stress represent the predominant contributors. In contrast, with more general distress, the impact of deployment traumatic stress plays a smaller role. A more comprehensive understanding of these emerging patterns of morbidity require more fine-grained analysis of the interaction between these symptoms to optimally characterise the emerging risk in this population.

In addition to documenting change in health and functioning over time in this cohort, a focused cross-sectional examination of head injury and TBI was also undertaken, including both self-reported prevalence and correlates, as well as a pilot neuroimaging investigation as part of the broader Impact of Combat Study. The raw prevalence of TBI and mTBI was somewhat higher than found in other studies, although the current study reported lifetime rather than deployment-specific TBI, accounting for this difference. There were very few differences between Transitioned ADF and 2015 Regular ADF members in terms of TBI rates or psychological symptom and functional impairment correlates of TBI in the cohort or subgroups. There were also almost no statistically significant findings from the neuroimaging investigation, although, in view

of the small number of participants, this was not surprising. The findings in relation to the possible associations between blast exposure and structural changes in the brain, in addition to the high self-reported prevalence of these events documented in the cohort more broadly, highlight the opportunity to use these data to examine the effects, both psychological and physical, of blast in this cohort in more depth.

9.10.1 Implications for Defence and DVA

A number of clinical and policy implications for Defence and DVA emerge from the findings of the Impact of Combat Study.

The weight of evidence points to the value of investing in continued longitudinal surveillance of this and other cohorts. As demonstrated in the findings of the present report and in *Mental Health Changes Over Time: a Longitudinal Perspective* (Bryant et al., 2019), surveillance of this cohort is enabling the identification of risk and protective factors for good and poor mental and physical health outcomes as they develop over time. This provides vital information for the development of risk mitigation and early intervention strategies to protect this cohort, as well as future cohorts of ADF personnel. In addition to allowing for the ongoing monitoring of the ADF workforce during service and following transition, longitudinal surveillance presents an opportunity to use the data collected to date to examine broader impacts of policy change, interventions and cultural shifts. Furthermore, throughout all Transition and Wellbeing Research Programme reports the risk of transition has been emphasised. Continued surveillance of these existing cohorts will also allow for prospective examination of transition outcomes in future follow-ups.

Internationally, there have been significant advances in understanding the neurobiological underpinnings of exposures to traumatic stress and the emergence of PTSD (see, for example, Bonanno et al., 2012; Eekhout et al., 2016; Eraly et al., 2014; Fikretoglu & Liu, 2012; Goodwin et al., 2012; Yehuda et al., 2015). It is important that screening and the development of predictive models for PTSD embrace this substantial emerging body of neuroscience. Of relevance here is the finding in relation to the pattern of dysregulation observed in inflammatory markers, which has not been fully investigated. In view of the role of inflammation in the aetiology of cardiovascular disease, auto-immune disease and psychiatric disorders, it is important that the clinical implications of these dysregulations be further examined in this cohort. The demonstrated alteration in inflammatory response in subcohorts is something that warrants further investigation because of its potential long-term implications for the health outcomes of the cohort.

The findings in this report also highlight the neurocognitive impacts of combat exposure. Given the extensive evidence about the neuropathology of PTSD and its effects on working memory and cognitive functioning more generally, this is a domain

that deserves further investigation. This is particularly relevant in the context of the ongoing concern about and increasing focus on the role of mTBI in the long-term health of military cohorts. It is worth remembering that PTSD is a condition associated with decreased total brain volume: these findings are therefore not trivial and should be part of any ongoing screening and monitoring of ADF members and veterans (Hedges & Woon, 2010).

To date, the data collected on this sample have undergone minimal analysis. It is crucial that the available data are extensively explored because of the potential for different genetic risks between militaries. The use of epigenetics to predict the risk of PTSD is being embraced in other military populations: if Defence and DVA are going to be able to respond to emerging concerns in this area, these dimensions of the impacts of combat exposure should be assessed in the future. The value of establishing baseline measures before and after deployment for this cohort should not be underestimated. With emerging developments and technology in neuroscience, further investigation of this cohort, and the stored serum, has significant contributions to make to better understanding the future health and welfare of ADF members.

More generally, the findings also highlight the importance of regular screening for changes in psychological and physical health and the fact that this needs to occur not only in the period immediately following deployment but also throughout a person's military career and following transition. The ADF has recently enhanced its mental health screening continuum to include a Periodic Mental Health Screen, administered in a primary health care setting. This will ensure that the psychological wellbeing of ADF personnel is being monitored more frequently – not just after deployment or exposure to a critical incident. Health and mental health professionals administering these screening tools and the regular physical health screens need to be adequately trained in the identification of key subsyndromal markers and how to effectively monitor the longitudinal course of disorders.

Finally, the study findings reinforce the importance of the work being done by Defence and DVA to link ADF personnel to available support services at the time of transition and to facilitate pathways to care as required after transition. Consideration should be given to increasing the opportunities for ongoing and proactive monitoring of the psychological and physical health of former members of the ADF – including those who are not exhibiting disorders. This should be done by trained and military-aware health and mental health professionals.

Annex A The study method

This annex outlines the study design, selection criteria, instrumentation, recruitment strategy and statistical procedures used for the Impact of Combat Study. Details of the Mental Health and Wellbeing Transition Study and the Family Wellbeing Study are provided in other Programme reports.

A.1 Summary of the research

The Transition and Wellbeing Research Programme is a joint research initiative of the Department of Veterans' Affairs and the Department of Defence. The purpose of the research is to examine the impact of contemporary military service on the mental, physical and social health of Serving and Ex-Serving Australian Defence Force members and their families. It builds on previous research and will inform effective and evidence-based health and mental health service provision.

The Programme was conducted by a consortium of six of Australia's leading research institutions, led by the Centre for Traumatic Stress Studies at the University of Adelaide and the Australian Institute of Family Studies. The consortium included researchers from Phoenix Australia Centre for Posttraumatic Mental Health, the University of New South Wales, Monash University and the University of Sydney.

The 2010 Military Health Outcomes Program (MilHOP) detailed the prevalence of mental disorder in the 2010 Regular ADF and deployment-related health concerns for those deployed to the Middle East Area of Operations between 2010 and 2012. Following the MilHOP, several research gaps were identified, including the mental health of Ex-Serving ADF members, Reservists, family members, and ADF members in high-risk roles, as well as the course of mental disorders and pathways to care for individuals over time.

The Programme aimed to address these research gaps in three separate but related studies the:

- Mental Health and Wellbeing Transition Study

- Impact of Combat Study

- Family Wellbeing Study.

A.2   Aims of the Programme

The Transition and Wellbeing Research Programme objectives were to:

- determine the prevalence of mental disorders among ADF members who transitioned from Regular ADF service between 2010 and 2014

- examine self-reported mental health status of Transitioned ADF and the 2015 Regular ADF

- examine the physical health status of Transitioned ADF and the 2015 Regular ADF

- assess pathways to care for Transitioned ADF and the 2015 Regular ADF, including those with a diagnosed mental disorder

- examine the factors that contribute to the wellbeing of Transitioned ADF and the 2015 Regular ADF

- conduct predictive modelling of the trajectory of mental health symptoms/disorder of Transitioned ADF and the 2015 Regular ADF, removing the need to rely on estimated rates

- investigate technology and its utility for health and mental health programs, including implications for future health service delivery

- follow up on the mental, physical and neurocognitive health and wellbeing of ADF members who deployed to the MEAO between 2010 and 2012

- investigate the social, physical and mental health and wellbeing of 2015 Ab initio Reservists (those who joined as Reservists and have served only in the Reserves)

- investigate the impact of ADF service on the health and wellbeing of the families of Transitioned ADF and the 2015 Regular ADF.

These objectives will allow Defence and DVA to:

- build on the 2010 MilHOP research to develop an understanding of how mental health changes and manifests during the re-adjustment phase post-separation

- develop insights into how to improve communication between contemporary veterans, DVA and Defence

- further develop the research outcomes and optimise the use of existing data sets within DVA and Defence in relation to improving the understanding of the mental health of Serving and Ex-Serving members and the access to clinical services and their outcomes

- develop the objective knowledge base of DVA and Defence staff and other parties interested in the mental health of serving and transitioned members

- improve mental health (and associated physical health) outcomes for Serving and Ex-Serving members across all age cohorts and allow a review of the optimal method of conducting scientifically valid and reliable research with the ADF and Ex-Serving members that is acceptable to the participants, the Ex-Serving community the ADF and DVA.

A.3   Samples

To achieve the aims of the broader research Programme, six overlapping samples were targeted for data collection. The current report uses only one of these – Sample 5, Combat Zone. The six samples are described below:

- *Sample 1: Transitioned ADF.* This sample consisted of all ADF members who transitioned from the Regular ADF between 2010 and 2014. This included those who transitioned into the Active and Inactive Reserves as well as those who had discharged completely from the Regular ADF. The sample was made up of three groups of Transitioned ADF members: MHPWS Transitioned ADF – ADF members who participated in the 2010 MHPWS as a Regular ADF member but have since transitioned; Combat Transitioned ADF – ADF members who participated in the MEAO Prospective Health Study between 2010 and 2012 and have since transitioned; and ADF members who have transitioned from the Regular ADF since 2010 and who were not part of the 2010 MHPWS or the MEAO Prospective Health Study. Results from these three groups were combined and weighted to represent the Transitioned ADF in 2015.

- *Sample 2: 2015 Regular ADF.* This sample consisted of three groups of Regular ADF members in 2015 who were invited to participate in the study: those who participated in the 2010 Mental Health Prevalence and Wellbeing Study and were a Regular ADF member in 2015; those who participated in the MEAO Prospective Health Study between 2010 and 2012 and were a Regular ADF member in 2015; and a stratified random sample of Regular ADF members from 2015 who were not part of the 2010 MHPWS or the MEAO Prospective Health Study. Results from these three groups were combined and weighted to represent the 2015 Regular ADF.

- *Sample 3: Ab-initio Reservists.* This sample consisted of all ADF members who joined the ADF Reserves, who continue to serve in a Reserve capacity, and who have never been a serving Regular ADF member.

- *Sample 4: ADF families.* This sample consisted of ADF families nominated by 2015 Regular ADF and Ex-Serving ADF members participating in the Programme.

Two MilHOP samples, which were incorporated in samples 1 and 2 above for the purposes of analysis, were also followed up as part of an ongoing program of longitudinal health surveillance:

- *Sample 5: Combat Zone.* The study sample consisted of 1350 current and Ex-Serving members of the ADF who deployed to the Middle East Area of Operations after June 2010, returned prior to June 2012, completed a pre-deployment and/or post-deployment health survey as part of the MEAO Prospective Study in 2010–2012, and were included on the Military and Veteran Research Study Roll used in the Transition and Wellbeing Research Programme.[8] These 1350 participants were invited to complete a self-report survey. In order to determine which of the other study components individuals were eligible for (CIDI, blood testing, neurocognitive testing, MRI assessment), participants were grouped according to the assessments they completed as part of the MEAO Prospective Study (Time 1 and Time 2) and invited to complete additional assessments dependent on these groupings. That is, if participants completed a study element at Time 1 and/or Time 2, they were invited to do so again at Time 3. Eligible study participants located outside Australia were only invited to complete a survey. No additional exclusion criteria were applied to this sample.

  There were three nested subgroups in the sample (see Figure A1):

  – The Combat Zone Subgroup consisted of individuals within the broader study sample who participated in the physical testing component of the MEAO Prospective Study in addition to the self-report survey. These individuals were invited to participate in a CIDI (Phase 2) and blood test (Phase 3) in addition to the Impact of Combat Study self-report survey (Phase 1).

  – The Combat Role High-risk Subgroup consisted of individuals within the broader study sample who participated in the physical and neurocognitive testing components of the MEAO Prospective Study in addition to completing the self-report survey. These individuals were invited to participate in a CIDI (Phase 2), blood test (Phase 3) and neurocognitive assessment battery (Phase 4) in addition to the Impact of Combat Study self-report survey (Phase 1).

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[8] There were a number of individuals who completed the MEAO Prospective Health Study who were not included on the Study Roll. Various reasons included those who were deceased, those who had requested their details be removed from the MilHOP or the Military and Veteran Research Study Roll study rolls, those who did not provide consent for future contact at the time of their MilHOP participation, and those who opted out of TWRP.

- The mTBI subgroup was a targeted subgroup of individuals from within the Combat Role High-risk Subgroup. They were invited to participate in an MRI assessment (Phase 5) in addition to the self-report survey (Phase 1), CIDI (Phase 2), blood test (Phase 3) and neurocognitive test battery (Phase 4). These individuals were selected because they had previously completed a neurocognitive assessment as part of the MEAO Prospective Study and were identified as having high combat and blast exposure.

Figure A.1   Impact of Combat Study nested subgroups
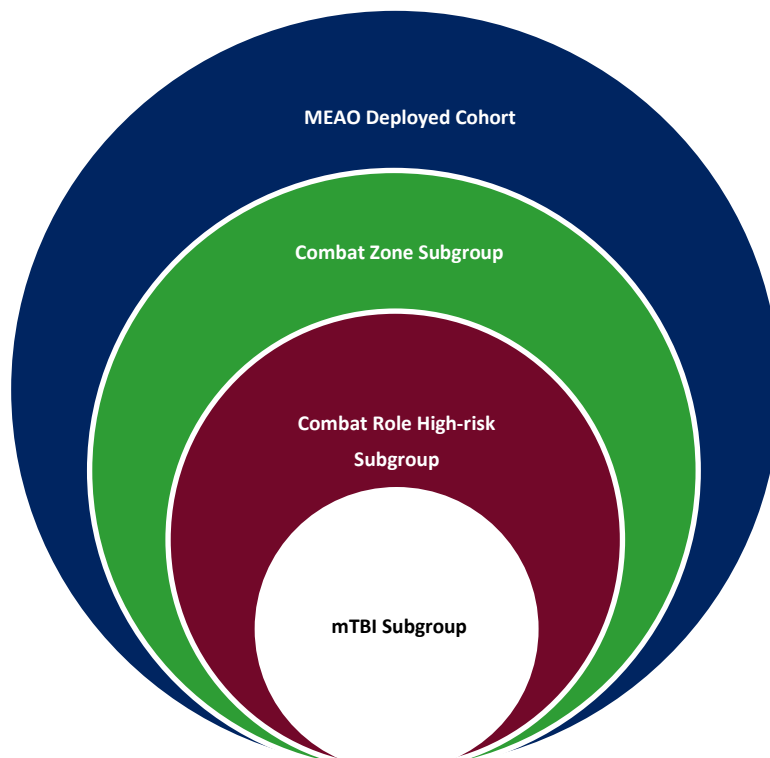
- *Sample 6: MHPWS.* This sample consisted of all individuals who participated in the 2010 MHPWS component of MilHOP (2010 ADF). It was made up of two groups: MHPWS Transitioned ADF – ADF members who participated in the 2010 MHPWS as a Regular ADF member but have since transitioned; and MHPWS 2015 ADF – Regular ADF members who participated in the 2010 MHPWS and were in the 2015 Regular ADF.

DVA and Defence commissioned a number of reports arising from the Research Programme; Table A.1 shows the samples each report covers. All samples were drawn from the Military and Veteran Research Study Roll, which is described in Section A.7.2.

Table A.1   Commissioned reports

Report	Programme goal	Samples	Data collection
Mental Health Prevalence Report: findings from the 2015 Mental Health and Wellbeing Transition Study	Establish baseline prevalence rates of mental disorders among ADF members who transitioned from full-time ADF service	• ADF members who transitioned from full-time ADF service between 2010 and 2014 • 2015 Regular ADF • Comparison with 2010 ADF and community, where appropriate	• Self-report questionnaire • CIDI (subgroup)
Pathways to Care Report: findings from the 2015 Mental Health and Wellbeing Transition Study	Pathways to mental health care for serving and Transitioned ADF members, including those with a mental health disorder, including: • how care is accessed • use patterns • stigmas and barriers	• ADF members who transitioned from full-time ADF service between 2010 and 2014 • 2015 Regular ADF	• Self-report survey
Physical Health Status Report: findings from the 2015 Mental Health and Wellbeing Transition Study	Physical health status of members of 2015 Regular ADF and Transitioned ADF, including: • symptom reporting, including pain and sleep • doctor diagnosed medical conditions • physical injuries • satisfaction with health	• ADF members who transitioned from full-time ADF service between 2010 and 2014 • 2015 Regular ADF	• Self-report survey
Family Wellbeing Report: findings from the 2015 Family Wellbeing Study	Experiences and perspective of family members on: • impact of military service on families • pathways to available care	• Nominated family members of serving Regular ADF members and ADF members who transitioned from full-time service between 2010 and 2014	• Self-report survey (quantitative component) • Semi-structured telephone interviews (qualitative component)
Technology Use and Wellbeing Report: findings from the 2015 Mental Health and Wellbeing Transition Study	Utility of technology for mental health and mental health programs, including implications for future health service delivery	• ADF members who transitioned from full-time service between 2010 and 2014 • 2015 Regular ADF	• Self-report survey
Impact of Combat Report: findings from the 2015 Impact of Combat Study	• Longitudinal impact of deployment to MEAO on psychological, biological and social factors • risk and protective factors • traumatic brain injury	• Serving and Ex-Serving ADF members who deployed to the MEAO between June 2010 and June 2012 and participated in MilHOP (Combat Zone sample)	• Self-report survey • CIDI (sub-group) • Neurocognitive and/or biological tests (subgroups) • MRI (subgroup)
Mental Health Changes Over Time: a Longitudinal Perspective Report: findings from the 2015 Mental Health and Wellbeing Transition Study	Longitudinal disorder development: • changes in symptom and disorder status over two time-points • predictors/outcomes of these changes	• 2015 Regular ADF • Transitioned ADF members who previously participated in MilHOP (MHPWS CIDI sample)	• Self-report questionnaire • CIDI (subgroup)
Transition and Wellbeing Research Programme Key Findings Report	Key findings across the Programme and implications for Defence and DVA	All	All

A.4 Study overview

The Impact of Combat Study was rolled out in concert with the Wellbeing Study and served as an interim time point in the longitudinal surveillance of the Middle East Area of Operations Prospective Study cohort. All participants who completed a pre-deployment survey as part of the MEAO Prospective Study were invited to complete a survey as part of the current investigation. Participants who were previously identified as having engaged in high-risk roles, who were therefore likely to experience deployment-related trauma or blast injury, and who underwent neurocognitive and/or biological testing as part of the MEAO Prospective Study were invited to do so again in the current investigation, in addition to the self-report survey. A further subgroup of personnel identified as having probable mTBI were targeted to undergo MRI testing in addition to the study components listed above. Finally, all three nested subgroups were also invited to participate in a structured diagnostic interview.

Interview data for the Transitioned ADF were weighted to ensure the representativeness of the prevalence estimates for key subgroups in the total Transitioned ADF population. Self-report survey data were also weighted to be representative of both the Transitioned ADF and the 2015 Regular ADF.

A.4.1 Background: MEAO Prospective Study methodology (Time 1 and Time 2)

ADF members who deployed to the MEAO after June 2010 and returned from that deployment by June 2012 were eligible to participate in the MEAO Prospective Study. In addition, a subsample of primarily combat personnel belonging to certain preselected units was invited to provide additional objective health measures – namely, physical tests (including blood tests) and/or neurocognitive assessments (see Figure A.2)

Figure A.2   MEAO Prospective Study assessment phases

SELF-REPORT SURVEY	PHYSICAL TESTING	NEUROCOGNITIVE TESTING
In order to be eligible to participate in the MEAO Prospective Study questionnaire component, individuals must have been members of the ADF and deploying to the MEAO after June 2010 and returning to Australia from deployment by June 2012. The MEAO Prospective Study was provided access to the following deploying units, all of which deployed at different times between June 2010 and June 2012 and for different lengths of time: HMAS *Stuart*, MTF2, MTF3, 1FCU, 1FSU, 2FSU, SOTG, 1CSU, 2CSU, C130s. Orion P3s. Individual	To be invited to participate in the physical testing, individuals must have been eligible to participate in the questionnaire component and be assigned to one of the following combat units: Navy ship, either of the two Special Forces Commando Units (1CDR and 2CDR), either of the two Special Forces Special Air Services (SAS) Units (1SAS and 2SAS), either of the two Army Mentoring Task Force Units (MTF2 and MTF3) and either of the two Army Force Communications Units (1FCU).	To be eligible to participate in the neurocognitive assessments, individuals must have been eligible to participate in the questionnaire component and be assigned to one of the following combat units: either of the two Special Forces Commando Units (1CDR and 2CDR), either of the two Special Forces Special Air Services (SAS) Units (1SAS and 2SAS), either of the two Army Mentoring Task Force Units (MTF2 and MTF3) or either of the two Army Force Communications Units (1FCU).

All data for the MEAO Prospective Study were collected at two points. In the first instance participants provided data not more than four months before their deployment (Time 1: pre-deployment) and then again on average 4.2 months after they returned home (Time 2: post-deployment) (see Figure A.3). Importantly, individual units deployed at varying times between June 2010 and June 2012 and for varied lengths of time. A major strength of this methodology was that it allowed for individuals to act as their own control, overcoming the need to identify a comparison group.

Figure A.3   Data collection timeline for MEAO Prospective Study and Impact of Combat Study
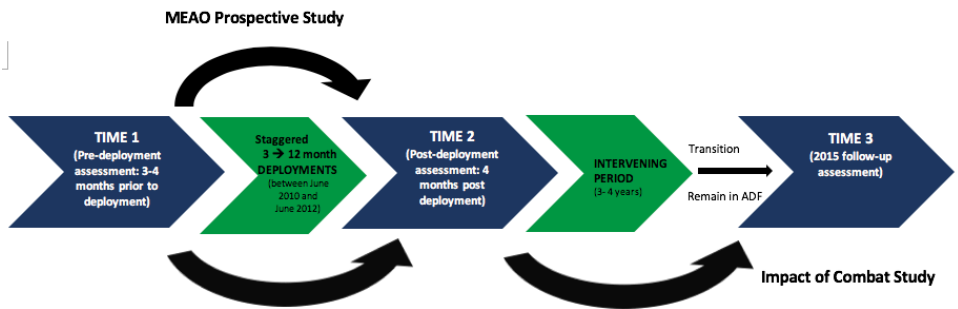
A.5   Measures

A.5.1   Phase 1: self-report survey

The Impact of Combat Study was rolled out in concert with the Mental Health and Wellbeing Transition Study and served as an interim time point in the longitudinal surveillance of the MEAO Prospective Study Cohort. In phase 1 of the research Transitioned ADF and 2015 Regular ADF personnel (Samples 1 to 5) completed a 60-minute self-report survey examining mental health problems, psychological distress, physical health problems, wellbeing factors, pathways to care and occupational exposures; this had been developed at the beginning of the study period in close consultation with DVA and Defence. Survey anonymity was preserved via the allocation of a unique study ID number to each participant. Participants belonging to the MEAO Deployed Cohort had previously completed a health survey as part of the MEAO Prospective Health Study in 2010 to 2012 and so were allocated their same MilHOP study ID number.

Participants could opt to complete the survey in one of two ways:

- *Online.* Participants were sent an email which included a secure link to an online invitation package containing the web-based survey. Participants could only access the survey by entering their unique study ID number and password, which was provided to them in the invitation email.

- *On hard copy.* Participants could opt to complete a hard-copy version of the questionnaire, which was mailed to their current postal address.

Each participating sample received a slightly different questionnaire relevant to their current ADF status – Transitioned ADF member, 2015 Regular ADF member, Ab-initio Reservist. In relation to demographics, Service and deployment history, however, the core validated measures of psychological and physical health remained the same and replicated where possible the measures previously administered as part of the MHPWS in 2010. This component of the design is crucial to the longitudinal comparisons over time and highlights the importance of a consistent approach to the oversight of research design for military and veteran populations.

Before roll-out, the online and hard-copy versions of the self-report survey were piloted on a select group of 2015 Regular ADF and Ex-Serving ADF members. Individuals in the pilot group were asked to provide detailed feedback on the content and adequacy of the survey and the usability of the system/form. Their comments and feedback were then incorporated in the final version of the survey. This ensured that there were no mistakes in the survey or glitches in the system before the study was rolled out.

Impact of Combat study self-report survey content

Part 1: Demographics and Service details

Part 1 of the survey was completed by the entire MEAO Deployed Cohort and comprised the following major sections:

- *Demographic information.* Participants were asked to provide information on gender, date of birth and highest educational qualification attained. These items were taken directly from the 2010 MHPWS (McFarlane et al., 2011b).

- *Household and family structure.* Participants were asked questions about their relationship status, household structure and children. Items in this section were derived from several sources, including the Timor-Leste Family Study (McGuire et al., 2012), the Household, Income and Labour Dynamics in Australia (HILDA) Survey (Watson & Wooden, 2002) and the 2014 Vietnam Veterans Family Study conducted by DVA (Forrest et al., 2014).

- *Financial status.* Items assessing participants' current financial status, including financial hardship, were taken from the HILDA Survey (Watson & Wooden, 2002) and the Health and Wellbeing Survey of Serving and Ex-Serving Personnel of the UK Armed Forces: Phase 2 (Fear et al., 2010).

- *Homelessness.* This section of the survey consisted of eight questions from the 2010 ABS General Social Survey (Australian Bureau of Statistics, 2011) that examined lifetime and recent episodes of homelessness. Items looked at the following:

  - participants' experiences of homelessness

  - reasons for homelessness

  - frequency of homelessness

  - details of their most recent experience of homelessness – reason for homelessness, time frame, recency

  - assistance sought during period(s) of homelessness and the helpfulness of these services

  - barriers to seeking support.

- *ADF service details.* Participants were asked a series of questions specific to their employment with the ADF, including the number of years served, current service status, hours worked per week, rank and Service. Depending on their rank and Service, participants were also asked a series of questions about their specialty and specific role in the ADF. Items in this section were taken from the ABS 2007 Survey of Mental Health and Wellbeing (Australian Bureau of Statistics, 2008) and the 2011 Australian Defence Force Exit Survey (Shirt, 2012).

- *Feelings about the ADF.* This section of the survey aimed to assess participants' level of organisational commitment. Four items were taken from Allen and Meyer's Affective Commitment Scale (Allen & John, 1990) and the other four items were developed by researchers for the study.

Transitioned personnel were also asked additional questions in part 1 pertaining to the following:

- *Employment status.* Participants were asked about their current employment activities. Examples of options are 'full-time work greater than or equal to 30 hours paid employment per week', 'home duties' and 'unemployed/looking for work'. Unemployed members were also required to provide a reason for their unemployed status. Items in this section were taken from the Young and Well Cooperative Research Centre standard suite of measures (Young and Well

Cooperative Research Centre, 2013) and the Health and Wellbeing Survey of Serving and Ex-Serving Personnel of the UK Armed Forces: Phase 2 (Fear et al., 2010).

Participants were also required to provide details about their current civilian employment, including the number of hours worked per week, the industry of employment and their main source of income. Items in this section were derived from the Health and Wellbeing Survey of Serving and Ex-Serving Personnel of the UK Armed Forces: Phase 2 (Fear et al., 2010), the Australian Defence Force Exit Survey (Shirt, 2012) and the HILDA Survey (Watson & Wooden, 2002). Additionally, participants were asked to indicate whether they had experienced a period of unemployment longer than three months since transitioning and when this period began. This item was taken from the Australian Gulf War Veterans' Follow up Health Study 2011 (Sim et al., 2015).

- *Reservist status.* Participants were asked about their Reservist status and, where relevant, to provide details about their Reservist employment, including their full-time/part-time status, the number of hours worked, and weeks away for Reservist work. Items in this section were taken from the Soldier Wellbeing Survey (Riviere, 2011; Thomas, 2010).

- *Year of transition.* Participants were asked to indicate what year they transitioned into Active Reserves/Inactive Reserves or out of the ADF. These questions were taken from the Health and Wellbeing Survey of Serving and Ex-Serving Personnel of the UK Armed Forces: Phase 2 (Fear et al., 2010) and the Australian Gulf War Veterans' Follow up Health Study 2011 (Sim et al., 2015).

- *Changes in relationship status.* Participants were asked to indicate whether their relationship status had changed since transitioning from full-time Regular ADF service. If divorced, separated or widowed since transition, participants were asked to provide a date. This item in the survey was taken from the Australian Gulf War Veterans' Follow up Health Study 2011 (Sim et al., 2015).

- *ADF separation details.* This section of the survey consisted of 2 parts. First, participants were asked about their discharge/resignation category. Examples of options are 'medical discharge', 'compassionate grounds' and 'end of fixed period engagement'. In part 2, participants were shown a comprehensive list of reasons for leaving the ADF and asked to mark all that played a role in their decision to leave. They were also asked to indicate the primary reason of those selected. Items in this section were based on the current exit survey used by the ADF (Shirt, 2012).

ADF Reservists were also asked questions about the following (this is not relevant to the current report):

- *Reservist details.* Participants were asked to provide details in relation to length of time served as a Reservist, Reservist status, periods of continuous full-time service, hours worked per week in the preceding month, weeks away in the past five years, and satisfaction with participation in the Reserves. Items in this section were derived from the Soldier Wellbeing Survey (Riviere, 2011; Thomas, 2010), the Health and Wellbeing Survey of Serving and Ex-Serving Personnel of the UK Armed Forces: Phase 2 (Fear et al., 2010) and the RAND Guard/Reserve Survey of Officer and Enlisted Personnel (Kirby & Naftel, 1998). Other items were developed specifically by researchers for use in the study.

- *Civilian employment.* Participants were asked a series of questions about the following in relation to their civilian role (if relevant): employer knowledge of Reservist role, employer attendance at Reservist events, employer support of military affiliation, impact of Reservist duties on civilian role, and a comparison of duties and responsibilities across Reservist and civilian roles. Items in this section were derived from the Soldier Wellbeing Survey (Riviere, 2011; Thomas, 2010), the Middle East Area of Operations (MEAO) Health Study: Prospective Study (Davy et al., 2012) and the ADF Exit Survey (Shirt, 2012). Information about current employment activities and details of civilian employment was also collected as described in the previous section for Transitioned members.

- *Contribution to the ADF.* Participants' perception of their contribution to the ADF was measured via a single item – 'how important do you think your contribution is towards the ADF?' Anchors ranged from 'not at all important' to 'very important'. This item was taken from the RAND Guard/Reserve Survey of Officer and Enlisted Personnel (Kirby & Naftel, 1998).

- *How the ADF deals with Reservists.* Participants' perceptions of how well the ADF deals with, understands and accepts Reservists were assessed via three items measured on a five-point scale ranging from 'very poor' to 'very good'.

- *Getting help (Reservist specific).* This section of the survey was developed by researchers and looked at mental health problems resulting from the Reservist experience, help sought for these problems, help sought and received from ADF services/non-Defence organisations, and benefits sought and received from DVA.

Part 2: Health and Wellbeing Survey

Part 2 of the survey was completed by the entire MEAO Deployed Cohort and contained the following major sections:

- *Deployments.* Participants were asked to provide detailed information about their deployment history with the ADF. Deployments were grouped into several categories: warlike/active service, non-warlike (peacekeeping) service, humanitarian/disaster relief, Defence aid and border protection. For each applicable deployment listed, participants were asked to indicate which country they were deployed to, the name of the operation, the dates they were deployed, the number of times they were deployed, the number of times they were deployed since 2011, the total number of months deployed, and whether they were deployed in a combat capacity. Items in this section were adapted from the 2010 MHPWS (McFarlane et al., 2011b).

- *Traumatic deployment exposures.* Participants were presented with a list of traumatic exposures and asked to indicate how many times they had experienced each one on deployment during their military career and since 2011. Response categories ranged from 'never' to '10+ times'. Examples of events are exposure to serious fear of encountering an IED, discharge of weapon in direct combat, and handling or seeing dead bodies. Items in this section were drawn from the MEAO Census Study (Dobson et al., 2012).

- *Environmental deployment exposures.* Participants were presented with a list of environmental exposures and asked to indicate how many times they had experienced each one on deployment during their military career and since 2011. Response categories ranged from 'never' to '10+ times'. Examples of events are exposure to smoke and/or dust, fumes or fuels, chemicals, hazardous materials, local food or water, and noise. Items in this section were drawn from the MEAO Census Study (Dobson et al., 2012).

- *Quality of life.* This section of the survey consisted of three items that assessed general health, satisfaction with health, and quality of life. General health was measured via the first item of the Short Form 36 Health Survey (SF36) (Ware & Sherbourne, 1992), referred to as the Form 1 (SF1). The SF1 is a single item that is increasingly being used in population studies as an indicator of overall health status. Items assessing general health and satisfaction with health were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015).

- *Depression.* Self-reported depression was examined using the Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al., 2001). The nine items of the PHQ-9 are

scored from zero to 3 and summed to give a total score between zero and 27. The PHQ-9 provides various levels of diagnostic severity, with higher scores indicating higher levels of depression symptoms.

- *Generalised anxiety disorder.* Generalised anxiety disorder was measured via the Generalised Anxiety Disorder 7 (GAD-7) (Spitzer et al., 2006). Each of the seven items is scored from zero to 3, providing a total generalised anxiety score ranging between zero and 21. Participants were asked to rate each item in the GAD-7 in relation to the preceding two weeks only.

- *Sleep problems.* Self-perceived insomnia was examined via the Insomnia Severity Index (Bastien et al., 2001), which comprises seven items assessing the severity of sleep onset and sleep maintenance difficulties, satisfaction with current sleep pattern, interference with daily functioning, noticeability of impairment attributed to the sleep problem, and degree of distress or concern caused by the sleep problem. Each item is rated on a zero to 4 scale and the total score ranges from zero to 28. A higher score suggests more severe insomnia.

- *General psychological distress.* The Kessler Psychological Distress Scale (K10) (Kessler et al., 2002) is a short 10-item screening questionnaire that yields a global measure of psychological distress based on symptoms of anxiety and depression experienced in the most recent four-week period. Items are scored from 1 to 5 and are summed to give a total score between 10 and 50. Various methods have been used to stratify the scores of the K10. The categories of low (10–15), moderate (16–21), high (22–29) and very high (30–50) that are used in this report are derived from the cut-offs of the K10 that were used in the 2007 ABS Australian National Mental Health and Wellbeing Survey (Slade et al., 2009) and were used to identify levels of psychological distress in the 2010 ADF Mental Health Prevalence and Wellbeing Study (McFarlane et al., 2011b).

- *Anger.* The Dimensions of Anger Reactions Scale (DAR- 5) (Forbes et al., 2004) is a concise measure of anger. It consists of five items that address anger frequency, intensity, duration and aggression and interference with social functioning. Items are scored on a five-point Likert scale, generating a severity score ranging from 5 to 25, with higher scores indicative of worse symptomatology. This scale has been used previously to assess Australian Vietnam veterans, as well as US Afghanistan and Iraq veterans, and shows strong unidimensionality and high levels of internal consistency and criterion validity.

- *Physical violence.* Items dealing with participants' personal experiences with physical violence or threatened violence were taken from the 2010 MHPWS (McFarlane et al., 2011b).

- *Suicidal ideation and behaviour.* Twelve-month suicidal ideation and behaviour were assessed via four items that looked specifically at suicidal thoughts, plans and attempts. Three of the items were adapted from the National Survey of Mental Health and Wellbeing (Australian Bureau of Statistics, 2008) and the final item was devised by researchers for use in the current study.

- *Perceptions of mental health.* Items dealing with participants' perceptions of their current and future physical and mental health were developed by researchers for use in the study.

- *Lifetime exposure to traumatic events.* This was examined as part of the posttraumatic stress disorder module of the CIDI 3.0 (Haro et al., 2006). Participants were asked to indicate whether or not they had experienced the following traumatic events: combat (military or organised non-military group); being a peacekeeper in a war zone or a place of ongoing terror; being an unarmed civilian in a place of war, revolution, military coup or invasion; living as a civilian in a place of ongoing terror for political, ethnic, religious or other reasons; being a refugee; being kidnapped or held captive; being exposed to a toxic chemical that could cause serious harm; being in a life-threatening automobile accident; being in any other life-threatening accident; being in a major natural disaster; being in a man-made disaster; having a life-threatening illness; being beaten by a spouse or romantic partner; being badly beaten by anyone else; being mugged, held up, or threatened with a weapon; being raped; being sexually assaulted; being stalked; having someone close to you die; having a child with a life-threatening illness or injury; witnessing serious physical fights at home as a child; having someone close experience a traumatic event; witnessing someone badly injured or killed or unexpectedly seeing a dead body; accidentally injuring or killing someone; purposefully injuring, torturing or killing someone; seeing atrocities or carnage such as mutilated bodies or mass killings; experiencing any other traumatic event. For each applicable event participants were asked to provide further information about the following: their age the first and last time the event took place, the number of times each event had taken place, the number of times each event was related to their ADF service, and the number of times each event had taken place since 2011. Participants were then required to indicate which of the events they indicated 'yes' to was their worst event.

- *Posttraumatic stress disorder.* The Post Traumatic Stress Disorder Checklist – civilian version (PCL-C) (Weathers et al., 1993) is a 17-item self-report measure designed to assess the symptomatic criteria of PTSD according to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV). The 17 questions are scored from 1 to 5 and are summed to give a total symptom severity score of between 17 and 85. An additional four items from the newly released

PCL-5 were also included, giving researchers flexibility to also measure PTSD symptoms according to the most recent definitional criteria.

- *Recent life events.* Participants completed a modified, 15-item version of the List of Threatening Experiences (Brugha et al., 1985). This brief questionnaire is frequently used to assess recent stressful life events. Participants were asked to indicate 'yes' if the event had occurred in the preceding 12 months and whether or not it was still having an effect on their life. Examples of events are 'your parent, child or spouse died', 'you had a major financial crisis' and 'you broke off a steady relationship'.

- *Alcohol use.* Alcohol consumption and problem drinking were examined using AUDIT (the Alcohol Use Disorders Identification Test) (Saunders et al., 1993), a brief self-report screening instrument developed by the World Health Organization. This instrument consists of 10 questions to examine the quantity and frequency of alcohol consumption, possible symptoms of dependence, and reactions or problems related to alcohol. The AUDIT is an instrument that is widely used in epidemiological and clinical practice for defining at-risk patterns of drinking (Babor et al., 2001). Currently the recommended WHO risk categories are used with ADF populations and are also therefore the scoring categories used in this study. This process identifies four bands of risk: Band 1 (scores of 0 to 7) represents those who would benefit from alcohol education; Band 2 (8 to 15) represents those that are likely to require simple advice; Band 3 (16 to 19) are those where counselling and continued monitoring is recommended; Band 4 (20 to 40) requires diagnostic evaluation and treatment, including counselling and monitoring (Babor et al., 1989; Babor et al., 2001).

  Two additional supplementary items of the AUDIT were included in the questionnaire as well as additional items on consumption to ensure comparability with the Australian National Health Survey 2011–2012 (Australian Bureau of Statistics, 2012).

- *Tobacco use.* Items assessing tobacco use were taken from the 2013 National Drug Strategy Survey (Australian Institute of Health and Welfare, 2014) and the 2010 MHPWS (McFarlane et al., 2011b). Participants were asked a series of questions about their past and present tobacco use, including frequency of use, the ages they started and stopped smoking daily, and the types of tobacco products they had smoked in the preceding year.

- *Drug use.* Twelve-month and lifetime drug use in Transitioned ADF only was measured using modified items from the 2013 National Drug Strategy Survey (Australian Institute of Health and Welfare, 2014). Transitioned ADF were asked a series of questions about two categories of drugs – illicit drugs (including

meth/amphetamines, marijuana, heroin, methadone or buprenorphine, cocaine, hallucinogens, ecstasy, ketamine, GHB, inhalants, opiates, opioids) and prescription drugs (including painkillers/analgesics, tranquilisers/sleeping pills) for non-medical purposes (where the term 'non-medical purposes' was defined as either alone or with other drugs in order to induce or enhance a drug experience). Participants were asked if they had ever used these drugs in their lifetime or the preceding 12 months and the age at which they first used them.

- *Functioning.* Functional impairment was assessed via the Sheehan Disability Scale (Sheehan, 1983), a five-item self-report measure of disability due to mental health symptoms in three inter-related domains – work/school, social life and family life. The three items assessing impairment in the three domains are scored from zero to 10 and can yield a total global functional impairment score of between zero and 30.

- *Getting help.* This section of the survey was developed by study investigators with specific knowledge and experience in the field. Other items were taken from the National Survey of Mental Health and Wellbeing (Australian Bureau of Statistics, 2008), the CIDI 3.O (Haro et al., 2006) and the 2010 Mental Health and Wellbeing Prevalence Study (McFarlane et al., 2011b) and modified by investigators to suit the current research.

  - *Means of informing/assessing and maintaining mental health.* The first series of questions looked at specific help-seeking strategies adopted by participants to inform/assess and maintain their mental health in the preceding 12 months and whether or not they found these strategies helpful. The 32 items looking at ways in which people informed/assessed their mental health were developed specifically for the study by researchers. The four items looking at the ways in which people maintained their mental health were taken from the CIDI 3.0 (Haro et al., 2006). A single item asked participants to indicate their preferred means of receiving information about their mental health. Options included via telephone, the internet, or in person (face to face). This item was developed by researchers for use in the study.

  - *Barriers and stigmas in relation to care.* Participants were asked to rate on a five-point scale the degree to which a list of 'concerns' might affect their decision to seek help. Anchors ranged from 'strongly disagree' to 'strongly agree'. Items in this section were taken from the 2010 MHPWS (McFarlane et al., 2011b), the Canadian Air Forces Recruit Mental Health Service Use Questionnaire (Fikretoglu et al., 2014) and the Solider Wellbeing Survey (Riviere, 2011; Thomas, 2010), with several additions by investigators.

Examples of items are 'I wouldn't know where to get help', 'it's too expensive' and 'I don't trust mental health professionals'.

This section of the survey also included a question that tapped into unmet needs for help. The question targeted individuals who expressed concerns about their mental health but never sought help. Participants were presented with a list of seven barriers and asked to indicate how much they disagreed with each one on a five-point scale ranging from 'strongly disagree' to 'strongly agree'. Examples of statements are 'I can still function effectively' and 'I didn't know where to get help'.

Items addressing barriers to care in both of sets of questions fell into eight categories: perceived control, self-stigma, public stigma, perceived stigma, mental health literacy, physical barriers to care, career barriers and concerns about mental health.

Items addressing participants' concerns about their mental health were developed specifically for the study by investigators.

- *Assistance with mental health.* Items addressing assistance sought for mental health were taken from the 2010 MHPWS (McFarlane et al., 2011b).

- *Help received/pathways into care.* Participants were asked whether they had ever sought or received help from the following list doctors or professionals for their own mental health in the preceding 12 months or outside the preceding 12 months: general practitioner/medical officer, psychologist, psychiatrist or other mental health professional. For each of the professionals listed, participants were asked to indicate what services they received, whether they were satisfied with the services and what compensation (if any) was received. These items were taken from the CIDI (Haro et al., 2006) and adapted for use in the current study.

  Participants were also asked whether they had used the following services in the preceding 12 months or outside the preceding 12 months: inpatient treatment, hospital admission; hospital-based PTSD program; residential alcohol and other drug program. For each of the treatments/programs listed, participants were asked to indicate whether they were satisfied with the service and how the service was paid for. These items were taken from the CIDI (Haro et al., 2006) and adapted for use in the current study.

- *Satisfaction with mental health services received.* Participants were asked to rate their satisfaction/dissatisfaction with a series of factors associated with receiving mental health care/services. Items included accessibility, cost, location,

effectiveness, health professional competence, health professional friendliness, convenience, confidentiality and the Medicare cap. Participants were required to provide answers in relation to their experiences in the preceding 12 months only.

– *Doctor-diagnosed mental health conditions.* This section of the survey asked participants about mental health problems or conditions they had ever been diagnosed with or treated for by a medical doctor over their lifetime. If a participant said 'yes' to any of the items, they were also asked to specify the year they were first diagnosed, whether they had been treated by a doctor for the condition in the preceding year, and whether they had taken medication for the condition in the preceding month. Items in this section were derived from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015).

– *Undiagnosed mental health conditions.* Participants were presented with a list of mental disorders and asked to indicate whether they currently had (or had ever had) each disorder without having been diagnosed or treated for it. Conditions included alcohol abuse or dependence, drug abuse or dependence, stress or anxiety, depression and PTSD. This question was developed by researchers at the Centre for Traumatic Stress Studies.

– *Help-seeking latency.* In order to assess help-seeking latency, participants were asked to indicate when they first sought help for their own mental health. Options included 'within 3 months of becoming concerned' or 'within 1 year of becoming concerned'. Alternatively, participants were able to specify the number of years since becoming concerned. This item was developed by researchers for use in the study.

– *Recommendation to seek help/assistance with seeking help.* This section of the survey consisted of two questions. The first asked participants whether someone else suggested that they seek help for their mental health condition. The second asked participants whether someone else practically assisted them in seeking care. Options included their GP, medical officer, partner, other family member, friend/colleague, or their supervisor/manager/commander. These questions were developed by researchers for specific use in the study.

• *Reasons for seeking care.* Participants were asked to indicate what primary and secondary reason lead them to seek care. Examples are 'anger', 'depression' and 'gambling'. The questions were developed by researchers for specific use in the study.

• *Health professionals.* In this section of the survey participants were presented with an exhaustive list of health professionals and asked to indicate which of them they

had consulted for their own health in the preceding 12 months. Participants were also asked to indicate how many times they had consulted a general practitioner and/or specialist doctor in the last preceding two weeks. All items in this section were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015).

- *Family and children.* This section of the survey consisted of several scales looking at participants' relationships with their family and children:

    - Family support and strain were assessed via items of relevance from an adapted version of the Schuster Social Support Scale (Schuster et al., 1990). Affective support was indicated by responses to questions about how often family made them feel cared for and how often family expressed interest in how they were doing. Negative interactions were indicated by responses to questions about how often family made too many demands on them, how often family criticised them and how often they created tensions or arguments with them. All items were answered on a four-point Likert-type scale ranging from 'often' to 'never'.

    - Items assessing participants' relationship with their current partner, arguments with their current partner and abuse experienced by their partner were taken from the Timor-Leste Family Study (McGuire et al., 2012).

    - A single item looking at how often participants had contact with family members not living with them was taken from the 2014 Vietnam Veterans Family Study (Forrest et al., 2014).

    - Participants were asked to indicate whether their relationship status had changed since 2011. If it had, they were asked to indicate whether they had married or started living with a partner, divorced (date), separated (date) or been widowed (date).

    - Items assessing the impact of military service on participants' relationships, employment, physical health, mental health and financial situation were also taken from the 2014 Vietnam Veterans Family Study (Forrest et al., 2014).

    - Two items assessing relationship satisfaction were taken from the HILDA Survey (Watson & Wooden, 2002). Participants were required to rate their relationship with their partner and their children on an 11-point Likert-type scale ranging from 'completely dissatisfied' to 'completely satisfied'.

- Items measuring conflict during childhood, parental mental health and parental substance abuse were taken from the Longitudinal Study of Australian Children (Gray, 2005).

- Global parental self-efficacy was assessed via a single item taken from the Longitudinal Study of Australian Children (Gray, 2005). Participants were required to rate their competency as a parent on a five-point Likert-type scale ranging from 'not very good at being a parent' to 'a very good parent'.

- Parental warmth was measured using six items from the Child Rearing Questionnaire (Paterson & Sanson, 1999). These items were also used in the Longitudinal Study of Australian Children (Gray, 2005). Participants were required to answer questions thinking about their first-born child aged between 4 and 17 who lived with them 50% or more of the time in the preceding six months. Participants were required to indicate how often each listed event took place on a five-point Likert-type scale ranging from 'never/almost never' to 'always/almost always'. Examples of events are 'how often did you hug or hold this child for no particular reason' and 'how often did you enjoy listening to this child and doing things with him/her'.

- Parental anger was measured using five items from the National Longitudinal Study of Children & Youth (Statistics Canada, 2003). Participants were required to indicate how often each listed event took place on a five-point Likert-type scale ranging from 'never/almost never' to 'all the time'. Examples are 'how often are you angry when you punish this child' and 'how often do you tell this child that he/she is not as good as the others'.

- *Friends and other social contacts.* This section of the survey consisted of several scales looking at participants' friends and social contacts:

  - Social support and strain were assessed via items of relevance from an adapted version of the Schuster Social Support Scale (Schuster et al., 1990). Affective support was indicated by responses to questions about how often friends made them feel cared for and how often friends expressed interest in how they were faring. Negative interactions were indicated by responses to questions about how often friends made too many demands on them, how often they criticised them, and how often they created tensions or arguments with them. All items were answered on a four-point Likert-type scale ranging from 'often' to 'never'.

  - A single item looking at how often participants had contact with friends not living with them was taken from the 2014 Vietnam Veterans Family Study conducted by the Department of Veterans Affairs (Forrest et al., 2014).

- A single item assessing how satisfied participants were with their friendships was taken from the HILDA Survey (Watson & Wooden, 2002). Participants were asked to rate their relationship on an 11-point Likert-type scale ranging from 'completely dissatisfied' to 'completely satisfied'.

- Questions looking at how many ex-service organisations participants belonged to and how these organisations benefited them were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015).

- *Resilience.* The Ohio State University Brief Resilience Scale (Smith et al., 2008a) was included to asses participants' ability to bounce back or recover from stress. Participants were asked to indicate the extent to which they agreed or disagreed with six anchored statements. The scale is scored by reverse coding items 2, 6 and 6 and finding the mean of the six items. The final item in this section assessed global happiness via the Delighted–Terrible scale (Andrews & Crandall, 1976), one of the more common approaches to collecting subjective quality-of-life data.

- *Gambling.* The Problem Gambling Severity Index (Stinchfield, 2007) is a widely used nine-item scale for measuring the severity of gambling problems in the general population. Each item is scored from zero to 3. The higher the total score, the greater the risk of problem gambling behaviour.

- *Driving.* Items examining risky driving were sourced from the Australian Institute of Family Studies (Smart et al., 2005) and looked specifically at driving over the speed limit and driving while affected by alcohol. Participants were asked to consider the last 10 times they drove and how many times in that period they engaged in risky driving behaviour.

- *Experiences with the law.* Participants were asked a series of questions about their experiences with the law, including whether they had ever been arrested, whether they had ever been convicted of a crime in a court of law, and whether they had ever been sent to prison. For any that applied, participants were also asked to indicate whether the event occurred before entry into the ADF, before transition from Regular ADF service, or since transition from Regular ADF service. Items were sourced from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015).

- *Internet use.* This section of the survey aimed to ascertain what role the internet played in improving the mental health and wellbeing of participants. Items were taken from the Young and Well National Survey (Burns et al., 2013) and looked specifically at internet use patterns, means of accessing the internet, use of the internet for social support, use of the internet for obtaining information relating to

mental health, use of the internet for managing mental health, barriers to using the internet for mental health, and the efficacy of the internet in meeting needs.

- *Emerging technologies.* The use of new and emerging technologies for health and wellbeing was assessed via a series of items developed by the Young and Well Co-operative Research Centre (Burns et al., 2013; Young and Well Cooperative Research Centre, 2013). Questions looked at participants' current use of new and emerging technologies, barriers to use, types of new and emerging technologies used, the use of new and emerging technologies for health and wellbeing improvement, reasons for using new and emerging technologies for health and wellbeing, other reasons for using new and emerging technologies, the types of new and emerging technologies participants would use if money were not a factor, and finally the early adoption of new technologies.

- *Head injuries.* This section of the survey consisted of two scales. First was a self-report version of the Ohio State University Traumatic Brain Injury Identification Method (OSU TBI-ID) (Corrigan & Bogner, 2007), which was adapted by researchers for specific use in the current Programme. The OSU TBI-ID is a standardised measure designed to elicit an individual's lifetime history of traumatic brain injury. Questions focus on the types of head/neck injuries incurred, the frequency of these injuries, whether the injuries occurred during military service or deployment, the number of times since 2011, symptoms experienced (for example, loss of consciousness, being dazed and confused, loss of memory), age the first and last time the symptoms occurred, frequency of symptoms, loss of consciousness related to a drug overdose or being choked, and finally the occurrence of multiple blows to the head in relation to a history of abuse, contact sports or ADF training/deployment. The second scale was a modified version of the Post-concussion Syndrome Checklist (Gouvier et al., 1992), which was used as part of the 2012 MEAO Health Study (Davy et al., 2012). This modified version of the scale required participants to indicate the degree to which they had experienced a list of 11 symptoms in the preceding four weeks as a result of an injury to their head or neck.

- *Physical exercise.* In order to assess physical activity, participants were asked to complete the Short Last 7 Days Self-Administered version of the International Physical Activity Questionnaire (IPAQ, 2002). Questions asked participants to indicate the number of days, the number of times, and the amount of time they spent doing vigorous, moderate and light physical activity in the preceding seven days, as well as the amount of time they spent sedentary.

- *Pain.* Items assessing pain intensity and disability were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015).

Participants were asked to answer a series of questions on a scale of 1 to 10 about their current pain, worst pain and average pain in the preceding six months. Participants were also asked to indicate how much their pain had interfered with their daily activities, their recreational/social activities, and their ability to work in the preceding six months.

- *Injuries.* This section of the survey was developed by researchers for the current Programme and looked at injuries sustained during an individual's military career that required time off work. For each injury type, participants were asked to specify how many injuries were sustained during their military career, how many were sustained whilst on deployment and how many were sustained during training. Participants were also asked to indicate all the body sites where the injuries occurred.

- *Respiratory health.* This section of the survey asked participants about any respiratory symptoms experienced in the preceding 12 months. Items were derived from the European Community Respiratory Health Survey 1 (Burney et al., 1994). Examples of symptoms that were assessed are wheezing or whistling, breathlessness, tightness in the chest, shortness of breath, coughing, phlegm, nasal allergies and asthma.

- *Physical health.* Items assessing current physical health were taken from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015). This 67-item adapted version of a self-report symptom questionnaire included respiratory, cardiovascular, musculoskeletal, dermatological, gastrointestinal, genitourinary, neurological and cognitive symptoms. For every symptom experienced in the preceding month, participants were also asked to provide an indication of symptom severity on a three-point Likert scale (mild, moderate, severe).

- *Doctor-diagnosed medical conditions.* This 44-item self-report questionnaire asked participants about medical problems or conditions they had been diagnosed with or treated for by a medical doctor in their lifetime. If a participant said 'yes' to any of the items listed, they were also asked to specify the year they were first diagnosed, whether they had been treated by a doctor for the condition in the preceding year and whether they had taken medications for the condition in the preceding month. Items in this section were derived from the 2011 Australian Gulf War Veterans' Follow up Health Study (Sim et al., 2015).

Distribution of the self-report survey

Recruitment for the study was staggered across the entire data collection period. Online invitation packages were distributed to participants in batches. The first batch of invitation emails was sent out in June 2015. Each email contained a unique study ID

number and token password, as well as a secure link to an online invitation package. This package contained the self-report survey and all associated study materials, including information sheets and consent forms. Invitation packs were uniquely tailored to participants' current serving status and eligibility criteria. Where email addresses were not available, or on request, hard-copy versions of the invitation package were posted to participants.

Follow-up of survey non-responders

A multifaceted approach to following up survey non-responders was used to maximise participation rates.

Email reminders were sent to all non-responders two, four and six weeks after the invitation package was distributed and one month before the survey was closed. Participants who preferred to complete a hard-copy version of the survey were directed to call or email the study team. This was specified in all reminder email correspondence.

SMS reminders were sent to all non-responders concurrently to alert them to their emails. This included members who had not yet begun the survey, as well as individuals who had partially completed it.

A selection of high-priority participants was targeted via a structured telephone follow-up process. These participants were members of the MHPWS CIDI cohort. It was important to maximise the response rate for this longitudinal cohort with existing data points to enable mapping of the trajectory of disorder. Telephone follow-up was also extended to participants without email addresses, partial completers and other target groups with low response rates to ensure representativeness. Specifically, this included:

- Transitioned ADF members with a landline phone number but no email address or mobile number

- Transitioned ADF members with a landline phone number and Defence email address but no mobile phone number

- partial completers from all cohorts

- participants with bounced emails from sole non-Defence email addresses, with a landline phone number but no mobile number

- participants who nominated family members for the Family Study but did not provide contact details for their family

- all other Transitioned ADF members and Ab-initio Reservists who had not begun the survey.

Trained research staff at the Centre for Traumatic Stress Studies made the phone calls following a structured script. The calls were made at a variety of times during the day and evening to optimise contact opportunities. A maximum of 10 attempts were made to speak to each participant twice. Where no contact was made and a telephone message service was available, a reminder message was left on two of these 10 occasions only, along with the study free-call number and email address.

Hard-copy invitation letters containing the study free-call number and email address as well as a link to the online survey were sent to:

- all Transitioned ADF non-responders

- all Ab-initio Reservist non-responders

- all 2015 Regular ADF non-responders who did not participate in MilHOP.

A.5.2   Phase 2: the diagnostic interview

In phase 2 of the research a subsample of individuals was selected to participate in a one-hour telephone interview using the CIDI (Kessler & Ustun, 2004). The CIDI provided the research team with an assessment of mental disorders based on the definitions and criteria of two classification systems – The *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* and the International Statistical Classification of Diseases and Related Health Problems 10th revision (ICD-10) (World Health Organization, 1994). The CIDI was selected because of its highly structured nature and its very frequent use in epidemiological studies worldwide, including in the 2010 Mental Health Prevalence and Wellbeing Study, conducted by the Centre for Traumatic Stress Studies, and the 2007 National Survey of Mental Health and Wellbeing, conducted by the Australian Bureau of Statistics.

To be eligible for recruitment, potential interviewees must have completed the self-report measures and have consented to being contacted to participate in a telephone interview. Three specific groups were targeted:

- a stratified sample of ADF members who had transitioned out of full-time service since 2010. Transitioned ADF survey responders were invited to complete a CIDI based on their scores on the PCL and AUDIT screening measures, and demographic characteristics were used to further preference participants to ensure the CIDI sample represented the entire cross-section of population characteristics as far as was possible

- all MHPWS ADF members who were interviewed using the CIDI in 2010. This included individuals who met ICD-10 diagnostic criteria for either a 12-month ICD-10 affective, anxiety or alcohol disorder in 2010, as well as individuals who were subsyndromal or who had no disorder

- a sample of ADF members who participated in the MEAO Prospective Health Study between 2010 and 2012 (relevant to the current report).

CIDI recruitment

The CIDI was administered to consenting participants by a team of trained interviewers from the Hunter Research Foundation in Newcastle, New South Wales. Their diagnostic inter-rater reliability was closely monitored by supervisors based at the research centre throughout the study period.

Telephone calls were made at a variety of times during the day and evening, taking into account participants' preferences, so as to maximise contact opportunities. To ensure that the most recent contact details were used, a download of current phone numbers was obtained from PMKeyS immediately before the study began and intermittently throughout the interview period.

Participants were contacted by telephone using contact details obtained through the self-report survey, the Australian Institute of Health and Welfare, PMKeyS, or participants providing contact details and alternative contact details, either online or in hard copy, as part of MILHOP study.

The first telephone call was made using the primary phone number provided in the contact information sheet completed in phase 1. In the absence of this information, a phone number obtained from one of the sources listed above was used. A maximum of 10 attempts were made to speak to the participant before that participant was removed from the pool. When no contact was made, a reminder message was left on two of the 10 occasions, along with the study's free-call number and email address. Where telephone contact was made, research officers explained the aims, purpose and requirements of the interview, and if consent was granted an interview time was arranged.

Conducting the interviews

At the beginning of each interview participants were reminded that participation was voluntary; they could stop the interview at any point and could withdraw from the study at any time without any impact on their career or entitlements. If the participant agreed to proceed with the interview, verbal consent was recorded. Following this, the highly structured interview was conducted.

At the end of the structured interview, participants were given time to debrief and ask questions and were given interview-related feedback. If at any time the participant indicated they were feeling distressed or suicidal, interviewers implemented the relevant duty of care protocols.

12-month and lifetime ICD-10 mental disorders
The CIDI was used to assess the 12-month and lifetime ICD-10 rates for depressive episode, dysthymia, bipolar affective disorder, panic attack, panic disorder, agoraphobia, social phobia, specific phobia, generalised anxiety disorder, obsessive–compulsive disorder, PTSD, adult separation disorder, harmful alcohol use and dependence, suicidal ideation and behaviour, and intermittent explosive disorder.

Clinical calibration studies report that the CIDI has good validity (Haro et al., 2006). Throughout the report, ICD-10 prevalence rates are presented with hierarchy rules applied to directly compare them with the Australian national rates (Slade et al., 2009). For all ICD-10 disorders, the standard CIDI algorithms were applied; therefore, to qualify for a 12-month diagnosis, individuals would be required to meet lifetime criteria initially and then to have reported symptoms in the 12 months before the interview.

Lifetime trauma exposure
Lifetime exposure to trauma was examined as part of the PTSD module of the CIDI. The following criterion A events listed in the CIDI were examined: combat (military or organised non-military group); being a peacekeeper in a war zone or place of ongoing terror; being an unarmed civilian in a place of war, revolution, military coup or invasion; living as a civilian in a place of ongoing terror for political, ethnic, religious or other reasons; being a refugee; being kidnapped or held captive; being exposed to a toxic chemical that could cause serious harm; being in a life-threatening motor vehicle accident; being in any other life-threatening accident; being in a major natural disaster; being in a man-made disaster; having a life-threatening illness; being beaten by a parent or guardian as a child; being beaten by a spouse or romantic partner; being badly beaten by anyone else; being mugged, held up, or threatened with a weapon; being raped; being sexually assaulted; being stalked; having someone close to you die; having a child with a life-threatening illness or injury; witnessing serious physical fights at home as a child; having someone close experience a traumatic event; witnessing someone badly injured or killed or unexpectedly seeing a dead body; accidentally injuring or killing someone; purposefully injuring, torturing or killing someone; seeing atrocities or carnage such as mutilated bodies or mass killings; experiencing any other traumatic event; and experiencing any other event that the participant did not want to talk about.

A.5.3   Phase 3: Biological testing

Biological testing for the Impact of Combat Study was rolled out as part of the larger Transition and Wellbeing Research Programme, with the aim of collecting all data elements within a four-to-six-week window for each eligible participant.

Blood collection procedure

After being contacted by the research team, consenting participants were posted the relevant paperwork and directed to the nearest suitable collection centre to have their blood collected. Forty-four millilitres of blood (2 x 4.0 ml EDTA tubes, 1 x 6ml Li Hep tube, 4 x 8.5 ml serum tubes, 1 x 4ml K2 EDTA tube) was drawn from each participant in order to assess the markers shown in Table A.2.

Table A.2   Biological markers

Biological mechanisms and indices of disease/disorder	Blood chemistry and liver function Sodium, potassium, chloride, bicarbonate, anion gap, glucose, urea, creatinine, total cholesterol, urate, phosphate, calcium, albumin, globulin, total potein, bililrubin, BBT, ALP, ALP, AST, LD, CK, amylase, lipase
	Organophosphate exposure Red blood cell cholinesterase
	Total cell count (CBE) Haemoglobin, red cell count, packed cell volume, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, red cell distribution width, total white cell count and white cell differentiation counts and percentages (neutrophils, lymphocytes, monocytes, eosinophils, basophils, platelets)
	Erythrocyte Sedimentation Rate as part of CBE
	Cardiovascular risk factors Total cholesterol, high-density lipoproteins, glycated haemoglobin
Physiological and immunological changes arising from stress	Inflammatory mediators Interleukin 6, C-reactive protein, TNF alpha, interleukin 1
	Resilience markers Interleukin 4, interleukin 10, interleukin 28, neuropeptide-Y
	Stress hormones Cortisol, noradrenaline, adrenaline, glucocorticoid receptors

Blood collection was carried out by Sonic Healthcare Australia in accordance with strict protocols and procedures. Where collection took place on base, Sonic Healthcare was responsible for ensuring that the regular collection centre procedures for collecting blood were followed.

The collection procedure was as follows:

- Perform patient identification.

- Complete referral documentation.

- Select the appropriate tubes for each required test and perform specimen collection.

- Label tubes with participant study ID, date of birth, date/time of collection, ID of collector and attach lab ID barcode labels to referral and tubes.

- Verify participant ID and cross-check with list provided by CTSS, specimen labels and specimen legend.

- Check patient's wound.

- Discharge patient and process specimen for transport (if necessary).

Centrifugation, packing and freighting of blood samples

- Serum assigned for analysis at the Baune Psychiatric Neuroscience Laboratory was collected into 2 x 8.5 ml gold top serum gel tubes.

- After blood was collected the SST tubes were left to stand for at least 30 minutes (no more than an hour) before processing to allow for clotting. If the sample had not clotted after 30 minutes, collectors waited an additional 10 minutes and rechecked.

- All four serum tubes were then placed into the centrifuge and spun at 1800 g (rcf) for 10 minutes.

- 2 x spun SST, 1 LiHep, 2 x EDTA and 1 K2 EDTA were placed in the bio bag.

- The serum from the remaining 2 x SST tubes was then aliquotted into 10 x 1 ml Eppendorf tubes.

- Tubes were cryolabelled with ID, date and sample type.

- All samples and paperwork were placed in a courier bag on ice for the courier (where relevant).

- If the samples were collected on base, collectors placed all samples in an Esky for transport back to the laboratory

Once samples were processed and aliquotted, they were immediately frozen down to –80 degrees and stored securely. Tests of immunological and HPA axis function were performed at the Baune Psychiatric Neuroscience Laboratory, at the University of Adelaide. Serum samples assigned for analysis at the Baune Psychiatric Neuroscience Laboratory were shipped on dry ice from each state location to Adelaide each month. The remaining analyses – that is, blood chemistry, liver function, general blood work including total cell count and erythrocyte sedimentation rate, and cardiovascular system function – were performed by Sonic Healthcare Australia.

Results flagged as abnormal by the pathology company were forwarded to the Baune Psychiatric Neuroscience Laboratory and reviewed by a medical doctor. Participants

with confirmed abnormalities were given a copy of their test results along with a plain-language description and summary of the abnormalities, with advice to seek further medical attention from their personal GP, medical officer, or regional health service. Critically abnormal results were promptly communicated to the study manager, who, after consulting with the medical doctor, contacted the participant by phone.

Biological material was stored in a double de-identified manner during the course of the study, in password-protected, secure, monitored –80 degree freezers. Specimens were assigned a lab ID on collection and sent to the psychiatry neuroscience laboratory for processing. As part of processing, each incoming specimen received a unique barcode cryogenic label. Using Freezerpro, specimen data were entered into the database and linked to the unique barcode. Specimen data included age, gender, date of collection, sample type and volume of sample. The use of a unique numerical identification enabled a systemised approach in terms of de-identifying data records and uniform coding of all samples.

The keys linking study numbers to individuals' identifying information, self-report data, biological and other Defence-owned data were kept and maintained by CTSS in a facility that met Defence physical and information security requirements.

Measurement of blood pressure

Blood pressure was measured by a trained research officer using a calibrated and validated digital sphygmomanometer with appropriate-sized cuffs. For consistency, it was measured with participants in a seated position, their left arm supported at heart level (unless there was a contraindication, such as lymphoedema), after five minutes' rest and abstinence from food and caffeinated beverages (for a minimum of 30 minutes). BP was recorded as three serial measurements at intervals of at least one minute. An additional three serial measures were taken if the difference between the SBP and DBP readings was more than 8 mm Hg for SBP and more than 5 mm Hg for DBP. The mean of three acceptable BP measurements was used in the analysis. Heart rate was also recorded at this time.

A.5.4   Phase 4: neurocognitive testing

Participants were assessed using the standard suite of LabNeuro and IntegNeuro tests administered by the Brain Dynamics Centre at Westmead Millenium Institute. Tests were undertaken according to the Brain Resource International Database Methodology (Version 3: May 2009) (Brain Resource International Database, 2009). Participants were invited to participate in the neurocognitive battery of tests if they had completed one or two previous assessments as part of the MEAO Prospective Study.

LabNeuro tests assessed electrophysiological responses to resting and active cognitive states. Tasks were designed to activate certain cognitive functions, with resultant data

indicating electrical brain activity in response to the various stimuli. In contrast, IntegNeuro tests assessed outward performance on a range of cognitive tasks (for example, correct answers and number of errors). Importantly, participants might have differed in electrophysiological activation whilst not differing in observable performance. Thus these measures were complementary. For this reason some tasks were performed in both IntegNeuro and LabNeuro.

The entire neurocognitive assessment suite took participants about three hours to complete. This included set up, 50–60 minutes LabNeuro testing and 50 minutes IntegNeuro testing. For members belonging to the Combat Role High-risk Subgroup and the mTBI Subgroup located in Sydney (eligible for additional MRI testing – described in the next section), neurocognitive assessments were conducted at the Brain Dynamics Centre, Westmead Millennium Institute. Participants were scheduled in by research staff at the centre and underwent all testing components in the same block of time.

For members belonging to the Combat Role High-risk Subgroup located in Darwin, Perth or Townsville (not eligible for MRI testing) a mobile neurocognitive lab was hired from the Brain Resource Centre and transported to testing locations. The lab was set up for one to three weeks in each testing location and operated by one or two research staff. Biological testing, as described, took place at collection centres in each of the testing locations immediately preceding or following neurocognitive testing.

Neurocognitive data cleaning and preparation were carried out by the Brain Resource Company. Treated data were then provided back to CTSS for analysis.

LabNeuro testing

Measurements of brain and body function were recorded simultaneously during each acquisition. The measures included electrocortical (EEG, ERP), electrodermal (skin conductance level, skin conductance response), autonomic nervous system function (heart rate, respiratory rate) and motor response (reaction time) measures. Data were collected during rest conditions (eyes open and closed) and while performing activation tasks (for example, Visual Go/No-Go, processing of facial emotions, sustained attention, and visual working memory).

Participants were seated in a sound- and light-attenuated room and fitted with a QuickCap for EEG recording and 40-channel NuAmps with electrodes located at the following scalp sites: Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, Oz, O2.

Horizontal eye movements were recorded from electrodes placed 1.5 cm lateral to the outer canthus of each eye. Vertical eye movements were recorded with electrodes placed 3 mm above the middle of the left eyebrow and 1.5 cm below the middle of the

left bottom eyelid. Electrode impedance was generally maintained below 5 kOhms. EEG data were acquired using a continuous acquisition system, with a sample rate of 500 Hz with a 22-bit analog-to-digital converter (NuAmps). EEG data were recorded relative to the virtual ground and re-referenced offline to linked mastoids. EEG data were collected during both resting and task activation paradigms.

While participants were being set up for LabNeuro, they were asked to complete two questionnaires:

- *How are you today?* This questionnaire asked participants about recent activities including recency of nicotine, alcohol and recreational drugs; number of hours slept the previous night; time since last meal; menstrual cycle information. Date of birth and years of education were also checked by this software.

- *NEO-FFI.* The NEO-FFI distinguishes five distinct personality traits – conscientiousness, agreeableness, neuroticism, extraversion and openness.

The LabNeuro tasks (taken from BRID Methodology Manual V3 (Brain Resource International Database, 2009)) were as follows.

Participants were positioned directly in front of the computer screen at a distance of 60 cm, so that their eyes were in line with the centre of the screen. Pre-recorded task instructions were delivered in a standardised way using computer 'wav' files presented via headphones. The LabNeuro battery took approximately 50–60 minutes to complete (including instructions and practice time). The order of tasks was important because the tasks increased in cognitive demand. The following tasks were administered to participants, although only qEEG and working memory were examined for the current report:

(1) Resting EEG (eyes open) and (2) Resting EEG (eyes closed)
- *Overview*. The baseline EEG measure allowed for comparison between resting and active states of the brain.

- *Detail.* (1) Participants were asked to rest quietly, with their eyes open, and focus on the red dot on the computer screen in front of them. They were told the task would last for three minutes. (Note that the actual task duration is two minutes.) (2) Participants were asked to rest quietly, this time with their eyes closed, with their head in the same position as before. The rest tasks had no stimulus events. The data were partitioned using 'pseudo events' of 4096 milliseconds each.

(3) Auditory habituation

- *Overview.* Participants listened passively to repeated auditory stimuli. This task reflects brain–body response decrements to novel stimuli and is indicative of automatic learning.

- *Detail.* Participants were instructed to look at the red dot on the screen. They were told they would hear some sounds and were asked to ignore them. Ten tones (500 Hz) were presented with a 1 sec ISI followed by a change stimulus (1000 Hz) and then five repeats of the initial tones (500 Hz). Auditory habituation had two event types – habituation and distractors. The task duration was approximately two minutes.

(4) Auditory oddball

- *Overview.* Participants were presented with differing auditory tones and were required to ignore the low-pitched background tones and respond only when they heard the infrequent high target tones.

- *Detail.* Participants were presented with auditory stimuli binaurally, via headphones. A series of high and low tones were presented at 75 dB. Stimuli lasted for 50 ms, with an ISI of 1s. Rise and fall times of tones was 5 ms. Participants were instructed to press buttons with the index finger of each hand in response to 'target' tones (presented at 1000 Hz). They were instructed to make no response to 'background' tones (presented at 500 Hz). Participants were given a brief practice session to clarify the distinction between target and background stimuli. Speed and accuracy of responses was stressed equally in the task instructions. Two hundred and eighty background tones and 60 target tones were presented in a quasi-random order, the only constraint being that two targets could not appear consecutively. Auditory oddball had two epoch types – targets and backgrounds. The task duration was approximately six minutes.

(5) Go/No-Go

- *Overview.* The colour of the word 'press' was presented randomly in either red or green. Participants were required to press a response button when they saw the word 'press' in green (Go) but not to respond when the word 'press' was presented in red (No Go). This task assessed the executive functions of the pre-frontal cortex, in particular the ability to inhibit inappropriate automated responses.

- *Detail.* Participants were repeatedly presented with the word 'press' (for 500 ms). Stimuli had an ISI of 1sec. If the word appeared in red, participants were instructed to make no response. If the word appeared in green, participants were asked to respond (using the index finger of each hand). Speed and accuracy of responses were equally stressed in the instructions. The word 'press' was presented in the

same colour six times in a row. There were 28 sequences, 21 in green and seven in red, presented in pseudo-random order. Go/No-Go had two epoch types – go and no-go. The task duration was approximately five minutes.

(6) Visual tracking

- *Overview.* A red dot moved smoothly back and forth (horizontally) on the screen at a frequency of 0.4 Hz. Participants were required to visually track the dot as it moved. This task reflects eye movement and brain function during an automatic tracking task.

- *Detail.* Participants were instructed to follow the red dot with their eyes as it moved across the screen at 0.4 Hz but not to move their head. The visual tracking task had no stimulus events. Data were partitioned using pseudo-events of two seconds each. The task duration was approximately one minute.

(7) Letters passive primer

- *Overview.* This task was a passive primer to the Continuous Performance Test (n-back).

- *Detail.* Four letters (B, C, D, G) were presented in pseudo-random order on the screen (the letters were in white and the background was black). Participants were instructed that they did not have to do anything other than look at the letters. Letters only had one event type, referred to as targets. The task duration was approximately two minutes.

(8) Continuous performance test (n-back)

- *Overview.* A series of letters were presented one at a time. Participants were required to respond when the same letter appeared twice in a row. This task reflected sustained attention and working memory updating.

- *Detail.* Participants were presented with a series of white letters (B, C, D, G) on a black background for 200 ms (ISI = 2.5 sec). Participants were instructed to simultaneously press two buttons with each index finger, when the same letter appeared twice in a row. Speed and accuracy of responses were equally stressed in the instructions. There were 125 stimuli in total, 85 background letters and 20 pseudo-randomly presented target letters (that is, repetitions of the previous letter). Background stimuli elicited the working memory P450. Participants were given a brief practice session. This task had three epoch types – targets, backgrounds and distractors. The task duration was approximately eight minutes.

(9) Novelty task

This task was embedded in the Continuous Performance Test (n-back) above. A total of 20 distractor stimuli (black-and-white 1 x 1 cm chequerboards) were randomly interleaved with the letter stimuli. Participants were instructed to ignore the 'chequerboards'.

(10) Maze

- *Overview.* A dot-based maze was presented on the screen. Using a directional button box, participants were required to discover (by trial and error) a hidden path through the maze and remember it. This task reflected planning, foresight, error correction, visuo-spatial learning and memory.

- *Detail.* Participants were presented with a grid (8x8 matrix) of circles on the computer screen. The object of the task was to find the hidden path through the grid, from the beginning point at the bottom of the grid to the end point at the top. They were able to navigate around the grid by pressing the arrow keys. Participants were presented with one tone (and a red cross at the bottom of the screen) if they made an incorrect move and a different tone (and a green tick at the bottom of the screen) if they made a correct move. The maze was the same each time the participant did the task. The trial ended when participants made their way through the maze twice, without making any mistakes, or after eight minutes had elapsed. The task assessed executive function. Maze events were categorised as being either wrong or right. The event times corresponded to the times of each move (keystroke) within the maze.

(11) Startle/pre-pulse inhibition

- *Overview.* A series of loud tones were presented, half without warning, half with a pre- pulse. This task reflects the body's 'fight or flight' response.

- *Detail.* Participants were asked to sit comfortably in their chair and fixate on the red dot presented on the computer screen, ignoring any sounds they might hear. They were then presented with a series of acoustic startles (noise bursts of 50 ms at 100 dB, instantaneous rise and fall). These sounds were designed to elicit a startle response, which consisted primarily of the eye-blink reflex, measured by recording the muscle activity around the eye. Successive stimuli were separated by a random interval between 10 and 15 seconds. Some startle stimuli were preceded by 50 ms with a pre-pulse, which consisted of quieter noise burst (20 ms at 75 dB with a 5 ms rise and fall time). The pre-pulse had the effect of inhibiting the startle response and could be used to measure sensory gating mechanisms. There were eight pre-pulse stimuli and seven startle stimuli. There were two epoch types – prepulse and startle. The task duration was approximately five minutes.

(12) and (13) Emotion processing (conscious, unconscious)

- *Overview.* A series of facial expressions across a range of emotions was presented, which participants were required to process implicitly.

- *Detail.* (12) Unconscious: Participants were told they would see a series of different faces presented in pairs but that the first face of each pair would be presented briefly (10 ms) followed by a masking stimulus (190 ms), so that conscious awareness was prevented. Participants were told that they didn't need to do anything but pay attention. (13) Conscious: Participants were told they would see a different series of faces, but that these would be presented only one at a time. Again, they were instructed to sit and relax but to pay attention to the faces because they would be asked about them later. A startle condition (a loud audible tone) was also included in both the unconscious and conscious presentation periods. There were 24 epoch types – emotion, conscious/unconscious and startle/non-startle, giving 6 x 2 x 2 = 24 epochs. The six emotions were neutral, happy, fear, sad, angry and disgust. The total task duration was approximately 11 minutes.

IntegNeuro testing

IntegNeuro tasks assessed a profile of sensory–motor, language, attention, memory and executive functions. Participants were seated in a sound-attenuated room, in front of an IBM touchscreen computer. Tasks were administered using pre-recorded task instructions. The instructions included a computerised visual demonstration followed by a 'test trial' prior to acquiring the data. If the participant failed this trial the task instructions were automatically repeated and elaborated upon. A touchscreen system was used for most answers and wav. files to record spoken answers. The complete IntegNeuro testing battery took participants approximately 50 minutes to complete.

The IntegNeuro tasks (taken from BRID Methodology Manual V3) were as follows:

(1) Motor tapping

Using their right hand first, participants were required to tap a circle on the touchscreen with their index finger, heel of hand on the frame of the screen, as quickly as possible for 30 seconds as counted down by a clock icon on the screen (other fingers remained inert above the screen surface, palm down). The procedure was repeated with the left hand. Total task duration was approximately one minute.

Assesses: DVs included the number of taps and the SD of RT for each hand (tapping variability). The task assesses basic motor function, hand–eye coordination, fine movement speed, and manual dexterity.

(2) Choice reaction time

Participants were given a stimulus from a set of possible stimuli and had to match that stimulus to the appropriate response. One of four circles lit up in different positions on the touchscreen. Twenty trials were administered in pseudo-random sequence with a random delay between trials of two to four seconds. Immediately following presentation, participants were instructed to touch the illuminated green circle as quickly as possible. Task duration was approximately two minutes.

Assesses: DVs included average RT (ms) and RT variability (ms). This task assessed basic sensorimotor functions, visuomotor coordination, information processing speed, speed- accuracy trade-off and mapping of stimulus identification to the appropriate response.

(3) Time estimation

A black circle appeared on the screen, turning green for times varying between one and 12 seconds. Participants were required to attend to the screen and estimate the duration of the target trace on the screen, using keys on a fixed display touchpad at the bottom of the screen with the numbers one to 12. Stimuli were presented in pseudo-random sequence. Task duration was approximately three minutes.

Assesses: DVs included the ratio between over- and under-estimation of time (that is, 'proportional bias') and the SD of this ratio. This task assessed the ability to estimate time intervals without a clock and relates to the ability to preplan actions, decide temporal onset, monitor the time course of initiation and anticipate outcomes.

(4) Span of visual memory

Nine asymmetrically positioned squares on the touchscreen were lit up in a pseudo-random order. Four seconds later, participants heard a tone indicating that they had to reproduce the order in which the squares were previously lit by touching each square in sequence order, with only one attempt per trial. Sequence length varied between two and nine, with two trials for each length. The task was terminated after two failures of the same length or when all 18 trials were complete. The task duration was approximately five minutes.

Assesses: DVs included the maximum span correct (two to seven) and the total number correct. This task assessed non-verbal working memory – that is, the capacity to hold and sequence visuospatial information in short-term memory and maintain attention.

(5) Digit span

There were two parts to this task. Participants were presented with a series of digits flashed on the computer screen for 500 ms, separated by a one-second interval. Part 1: Forward – participants were required to recall the digits in same order as they were given using the touch pad. There was then a delay of five seconds until the next trial.

Part 2: Reverse – participants were required to recall the digits in reverse order. In both part 1 and part 2 the number of digits in each sequence was gradually increased from three to nine, with two trials of the same length at each level. Answers were recorded using .wav files. The task terminated when both trials of a single length failed. The total task duration was approximately six minutes.

Assesses: DVs included the total number of digits recalled on both tasks and the separate scores of the forward and reversed spans. The task assessed immediate recall (forward) and working memory operations (reverse). The digit span task assessed the ability to hold, retain and manipulate new verbal information. Healthy controls have forward spans in the five- to eight-digit range (for example, remembering telephone numbers and shopping lists).

(6) Memory recall and recognition

There were several parts to this task. In the first part participants were asked to repeat back in order a list of 12 words presented via headphones one second at a time (learning trial 1). The procedure was repeated three further times with the same 12 words (four trials in all). Words were closely matched on concreteness, number of letters and frequency. Answers were recorded through a microphone into .wav files. The participant was then presented with a second list of 12 distractor words (foils) and asked to recall that list. None of the words in the distractor list was phonetically or semantically related to the first list. After this distraction, participants were asked immediately to recall the 12 words from the original list. By this time approximately six minutes would have elapsed. About 25 minutes later, participants were asked again to recall the 12 words from the original list. The total number of words recalled across the four trials was recorded during scoring. The total task duration was approximately 11 minutes.

Assesses: DVs included immediate and delayed recognition scores (number of words correctly recognised across the learning trials and the delayed trial), recognition of list words against foil scores, learning rate, interference and repetition scores. This task assessed verbal learning, memory recall and recognition, and verbal self-monitoring.

(7) Verbal interference (word, colour)

Participants were presented with four coloured words, one at a time. Each word was drawn from the following set of four colours: red, yellow, green and blue. Below each coloured word was a response pad with the four possible names of the colours displayed in black and in fixed format. This task had two parts. In part 1 (word) participants were required to read the name of each coloured word as quickly as possible and touch the appropriate matching tab. In part 2 (colour), participants were required to name the contrasting colour of the word as quickly as possible and then

click on the appropriate tab. Responses were made on the screen by pressing on the appropriate word on the bottom screen tab. The total task duration was two minutes.

Assesses: DVs included total score (number of words correctly identified) and errors in parts 1 and 2. The first part of the task measured reading speed and accuracy for individual words. The second part measured the ability to inhibit inappropriate, well-learned, impulsive, automatic responses. The DV in each part was the number of words correctly matched with the name of the colour in part one and the colour of the ink in which the word was printed in part two.

(8) Spot the word

Participants were presented with two words simultaneously, side by side on the touchscreen. One of the two words was a valid word in the English language and the second was a non-word foil. Participants were required to identify which of the two words was the real word by touching that word as quickly as possible. The order of words was pseudo-randomised over trials. The task duration was approximately four minutes.

Assesses: The DV was the total number of words correctly identified against matched foils. Guessing would yield 50% accuracy. This task provided an estimate of pre-morbid intelligence prior to the onset of disorder or disease.

(9) Word generation (verbal fluency, semantic fluency)

Verbal fluency: Participants were instructed to name as many words as possible, beginning with a certain letter (most commonly F, A and S, for which word naming is relatively easy) in the space of a minute. Participants were asked not to use proper nouns or make variations to the same word stem (for example, 'run' and 'running'). Semantic fluency: Participants were asked to name as many animals as possible. Word generation was recorded in .wav files. The total task duration was approximately six minutes.

Assesses: DVs included the scores for each of three letters and the total number of animals generated. The task assessed verbal fluency – that is, an individual's capacity to produce a sustained stream of spontaneous speech.

(10) Continuous performance test (n-back)

To tap sustained attention, a series of similar-looking letters (B, C, D, G) were presented for 200 ms on the computer screen. The letters were separated by an interval of 2.5 seconds. If the same letter appeared twice in a row (target letters were defined as those identical to the previous letter), participants were required to press the response button on the touchscreen. There were 125 stimuli presented in total, 85 being non-target letters and 20 being target letters. Omission errors were defined as a failure to respond to target stimuli and thus reflected inattention, whereas commission

errors were responses to non-target stimuli and are thought to reflect impulsive tendencies. Speed and accuracy were equally stressed in the task instructions. The task duration was approximately six minutes.

Assesses: DVs included RT (ms), total errors, false positives (errors of commission) and false negatives (errors of omission). The task assessed the ability to maintain sustained attention and inhibit impulsive responding over an extended period. Additionally, the task assessed target detection and the ability to update information held in short-term memory.

(11) Switching of attention (digits, digits plus letters)

In part 1 participants were presented with a display of 25 digits and asked to touch the numbers in ascending numerical sequence (1,2,3 …) while the computer drew lines connecting the correct numbers as they were touched. In part 2 participants were presented with a pattern of 13 digits (1–13) and 12 letters (A–L) on the screen. They were required to press on the digits/letters alternatively, in ascending sequence (1–A–2–B, and so on). The computer then drew a fine line to connect each number or letter to the preceding digit or letter in the sequence. This allowed participants to visualise the path that they had touched. The total task duration was three minutes.

Assesses: DVs included time to completion and errors (digits, digits plus letters). Part 1 assessed visuomotor tracking and attention. Part 2 assessed the ability to sustain and control the direction of attention and switch attention from one over-learned task to another.

(12) Maze

Participants were presented with a grid (8x8 matrix) of circles on the computer screen. The object of the task was to identify the fixed, hidden path through the grid, from the beginning-point circle at the bottom of the grid in yellow to the end-point circle at the top in blue. Participants were able to navigate around the grid by touching the arrow keys on the directional button box. A total of 24 consecutive correct moves were required to complete the maze. Participants were presented with an X on the screen and the sound of a tone if they made an incorrect move and a different tone if they made a correct move. Only one maze was presented across trials. The task ended when the participant completed the maze twice without error or after 10 minutes (eight minutes for psychometrics in the lab) had elapsed, whichever came first.

Assesses: DVs included total errors, overrun errors, completion time and total trials taken. Off-path moves and failures to turn are the most important executive measures. This task measured how quickly participants learned the route through the maze and their ability to remember that route. This involved executive functioning; planning; the ability to choose, try, reject and adapt alternative courses of thought and action; visuospatial learning; and memory.

(13) Go/No-Go

The colour of the word 'press' was frequently presented in green (Go) and infrequently in red (No-Go). The object of the task was to respond each time the word 'press' appeared in green. Participants were required to inhibit their response when 'press' appeared in red. Task duration was approximately four minutes.

Assesses: DVs included accuracy, average RT (ms), false negatives (errors of omission, reflecting inattention) and false positives (errors of commission, reflecting impulsivity). The task assessed executive functioning and cognitive inhibition – that is, the ability to suppress well-learned, automatic responses.

(14) Emotion identification, emotion recognition

Participants were presented with a series of faces with different emotional expressions (fear, anger, disgust, sadness, happiness, and neutral). They were required to identify the emotion label corresponding to the expression of emotion shown by the face. The delayed recall task assessed memory for prior targets (previously seen faces) against foils. The total task duration was approximately four minutes.

Assesses: DVs included accuracy for each emotion, RT for each correctly identified emotion, and the incorrectly identified emotions for both identification and recognition. This task assessed emotional recognition, discrimination between emotions, and memory for emotional expression.

(15) Malingering

This task assessed the capacity to remember words presented on a computer screen. The design of the task ensured that participants should be able to get a certain percentage of the trials correct simply by chance. A failure to achieve chance level suggests a deliberate attempt to understate memory capacity.[9]

Data security and confidentiality

All neurocognitive data were identified by way of a Brain Resource Company (BRC) ID. This ID was the same ID assigned in previous waves of data collection, enabling the linkage of data from multiple time points from each participant. The BRC IDs were also linked back to participants' study IDs, enabling the pooling of data collected across all study components. For protected identity participants, the keys linking these BRC IDs to the study IDs, and individuals' identifying information, were kept by an appropriately secured administration officer from Defence. All hard-copy material associated with this study component has been retained in a Defence-approved secure storage facility at CTSS.

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[9] Refer to the *Brain Resource International Database (BRID) Methodology Manual* (Brain Resource International Database, 2009) for a full description of the IntegNeuro and Labneuro protocols being used.

A.5.5   Phase 5: brain imaging

A select group of participants who had previously completed a neurocognitive assessment as part of the MEAO Prospective Study and were identified as having high levels of combat and blast exposure (the mTBI Subgroup) were invited to participate in additional structural and functional magnetic resonance imaging.

MRI assessments took approximately one hour to complete and were conducted at the Brain Dynamic Centre, Westmead Millenium Institute, using the standardised Brain Resource International Database protocol. For participants who lived outside New South Wales, flights and accommodation were arranged by research staff at CTSS. Participants who completed this phase of the research were given a Visa gift card to compensate them for their time and expenses.

Structural MRI

sMRI measures the volume of grey matter (neurons), white matter (connections) and fluid-filled spaces in the brain. It also measures the local magnetic fields of water molecules in the brain. Water in different tissue types responds differently to applied magnetic fields: this enabled the measurement of structure at the millimetre scale.

Structural MRI scans were undertaken using parameters that allowed for two specific forms of analysis: diffusion tensor imaging (DTI) and susceptibility weighted imaging (SWI). These two forms of advanced imaging have been found to be differentially sensitive to different aspects of cortical pathology and complement each other.

- DTI is a form of magnetic resonance imaging that is extremely sensitive to subtle brain pathology, including axonal injury (MacDonald et al., 2011). It provides an objective, non-invasive measure of structural connectivity in the brain and deficits in white matter that can be indicative of brain injury as well as psychopathology (MacDonald et al., 2011; Song et al., 2014; White et al., 2008).

- SWI is a similarly sensitive and complementary technique for identifying subtle changes to brain pathology. It is particularly sensitive to bleeding in the grey and white matter boundaries, allowing the detection of more subtle injuries (for example, micro-haemorrhages) that might not be picked up using conventional imaging techniques.

Procedure

The BRID protocol acquires data using four different types of MRI contrast, each capable of revealing different aspects of brain cytoarchitecture. The four types of image are:

1. Spin-echo image. Reflects T2 MRI contrast. Tissue contrast is csf > grey > white.

2. Proton-density image. Reflects the concentration of water. Tissue contrast is csf > grey > white.

3. T1-weighted image. Signal intensity is low in tissue with a long T1 and high in tissue with a short T1. Contrast: white > grey > csf.

4. Diffusion tensor imaging. These data need to be processed before use and can give a variety of contrast that reflects the diffusion speed of water in brain tissue and also the local direction of diffusion in tissues. This can be used to generate measurements of connectivity (via axons) in the brain.

- Dual echo
  - axial orientation
  - 3 mm slice thickness
  - number of slices = 60 (no gap)
  - TR = 7529 ms
  - TE = !5/105
  - echo train = 7
  - flip angle = 180
  - FOV = 220 mm x 220 mm
  - pixel size = 0.87x 0.86
  - NEX = 1
  - other details – frequency direction = anterior posterior
  - acquisition matrix – 252 x 256, phase encoding L > R, 8/8 rectangular field of view
  - acquisition duration = 4 minutes 40 seconds

- T1 MPrage
  - saggital orientation
  - 1 mm slice thickness
  - number of slices = 180 (no gap)
  - flip angle = 12
  - TR = 9.7 ms
  - TE = 4
  - TI = 200
  - matrix = 256 x 256
  - FOV = 256 mm x 256 mm
  - pixel size = 1.00 x 1.00
  - NEX = 1
  - acquisition duration = 8 minutes 20 sec

- Repeat T1 MPrage (exactly as above)

- DTI
  - axial orientation (same as dual echo)
  - 6.5 mm slice thickness
  - number of slices = 28 (no gap)
  - TR = 160 ms
  - TE = 88 ms
  - b = 0, 1250 s mm-2
  - d (little delta) = 25 ms
  - D (big delta) = 31 ms
  - matrix = 128 x 128
  - FOV = 220 mm x 220 mm
  - averages = 4
  - other details – fat saturation on, 12 diffusion gradient directions
  - acquisition duration = 5 min

Processing of sMRI data

Data are saved as DICOM images then transferred to the central Brain Resource laboratory for processing.

Functional MRI

fMRI monitors changes in blood flow in the brain that indicate which areas are active during different tasks. fMRI relies on the contrast between the natural magnetic properties of oxygenated versus deoxygenated flow to provide a measure of blood oxygen level–dependent (BOLD) signal change in regions of the brain. Task-related changes in brain activity are measured at a time scale of about 2–3 seconds and a spatial scale of 1 mm.

Tasks

Functional MRI was acquired during cognitive tasks which paralleled some of the paradigms from the EEG testing discussed previously, thereby providing visualisation of processing to complement other measures.

(1) Go No-Go (5 mins). Subjects were repeatedly presented with the word 'press' (for 500 ms) on the screen. Subjects were instructed to press a response button with the index finger of each hand if the word appeared in the colour green but to not respond if the word appeared in red. Speed and accuracy of responses were equally stressed in the task instructions. This task tested the executive functions of the pre-frontal and orbito-frontal cortex – in particular, the ability to inhibit or suppress well-learned and inappropriate automatic responses.

(2) Oddball (5 mins). Subjects were presented with a series of high and low tones at 75 dB that lasted for 50 ms (with rise and fall times of 5 ms). They were instructed to ignore the low ('background') tones (presented at 500 Hz) and to press, with the index

finger of each hand, a response button only when they heard high infrequent ('target') tones, which were presented at 1000 Hz. Speed and accuracy of responses were equally stressed in the task instructions. The task allowed for the assessment of processing novel task-relevant information, whilst ignoring task-irrelevant information.

(3) Emotion: conscious (5 mins). Subjects were told they would see a different series of faces presented one at a time. Again, they were instructed to pay attention to the faces because they would be asked about them later. This task assessed brain and body perception of faces showing emotion (the face stimuli were from the 'Gur' set of emotions).

(4) Emotion: non-conscious (5 mins). Subjects were told that they would see a series of different faces presented in pairs but that the first face of each pair would be presented so briefly as to be barely visible. They were told to pay attention because they would be asked about the faces later.

(5) Working memory (5 mins). This task consisted of a series of letters presented to the subject on the computer screen. If the same letter appeared twice in a row (a 'target letter') the subject was required to simultaneously press response buttons with the index finger of each hand. Speed and accuracy of responses were equally stressed in the task instructions. In addition, intermittent chequerboard stimuli elicited 'novelty P300a' visual ERPs. The task is designed to assess sustained attention and working memory.

Acquisition and analysis

Functional MRI data were collected on a 3 Tesla GE scanner using gradient echo echo-planar imaging to depict BOLD (blood oxygen level–dependent) activity. We acquired 36 brain slices parallel to the AC-PC line (3 mm thick with 10% gap), 128 x 128 matrix: TR 3.5 sec, TE 40ms, and FOV 250 mm, which provided whole-brain coverage. Four 36-slice volumes (totally 12 sec) were acquired during each stimulus block and three initial dummy volumes were collected to ensure BOLD saturation. Previous signal-to-noise analyses confirmed sufficient SNR in amygdala to detect significant signal change with a 1.5T scanner. fMRI data was analysed with the most recent standardised methodology, Statistical Parametric Mapping (SPM-5). Scans were smoothed of movement artefact and standardised into MNI space. Random effects subtraction analyses were conducted exploring averaged blocked fMRI signals for relevant contrasts, the independent variable and baseline in each task. Correlations were conducted between symptoms and neural activity in regions of interest according to each task.

fMRI and sMRI participant requirements

As outlined, members belonging to the mTBI Subgroup were tested at the Brain Dynamics Centre, Westmead Millennium Institute. Participant requirements were as follows:

- On arrival, participants were asked to complete a safety questionnaire to ensure that they were fit and eligible to undergo the procedure. The presence of certain metallic objects and implants excluded individuals from an MRI scan.

- Before the scan, participants were asked to wear a cotton hospital gown and remove all metal objects from their body (that is, jewellery).

- The procedure involved lying on a moveable examination table that then slid into the MRI cylinder. This cylinder contained a magnet that created a powerful magnetic field and thus enabled images of the brain to be taken.

- Participants were instructed to lie completely still during the first part of the scan since any movement would blur or distort the images. Participants were asked to complete some short tasks while in the scanner in the second part of the scan.

A.6 Unit-level perturbation of Medical Employment Classification values

A.6.1 Methodology

Due to the nature of the consent provided for individuals on the Study Roll, access to identified data for weighting purposes required the consent of the individual participants. The Australian Institute of Health and Welfare carried out a perturbation approach that provided each non-consenting record with a releasable MEC value. Perturbation used the observed values of MEC for the non-consenters to give an appropriate value to each non-consenting record. This was achieved simply by fitting a model using releasable data items as predictors in a model of MEC using the non-consenters. The model used was a logistic regression model. This resulted in a set of probabilities of each record taking on MEC values. A Monte Carlo approach used these probabilities to randomly assign a synthetic MEC value to each record. These synthetic MEC values reflect each individual's characteristics. The generation was constrained so that aggregate totals remained consistent with totals of unperturbed values.

The perturbation approach allowed the unit records to better reflect the MEC status of individuals. This allowed researchers to use the unit records to undertake more accurate analyses and tabulations.

The unit record perturbation allowed for tabulation and analyses. The perturbed values did not assume a broad level of homogeneity within the combinations of

variables as an aggregate weighting approach; rather, they allowed the individual characteristic of each person to inform the perturbed value they were assigned.

A.6.2   Results

The perturbation process was constrained at the source level. Tables A.3 and A.4 show that this was achieved, as the counts of 'fit', 'unfit' and 'missing' were the same for both the original and the perturbed values.

The missing values were assumed to happen at random within the source file. This meant that a participant's original missing value could be given to any other participant, regardless of their gender, Service, rank or age. As a result, the number of 'fit' and 'unfit' totals at these constraining levels for the perturbed data do not exactly line up with the original totals (see Table A.4 for totals by Service type).

Table A.3   Counts of categories, by source

Source	Original MEC value			Perturbed MEC value		
	Fit	Unfit	Missing	Fit	Unfit	Missing
ABIN	138	7	0	138	7	0
CURR	891	196	2	891	196	2
TRAN	271	159	1	271	159	1

Table A.4   Counts of categories, by Service type

Service	Original MEC value			Perturbed MEC value		
	Fit	Unfit	Missing	Fit	Unfit	Missing
Navy	613	191	3	614	193	0
Army	254	63	0	255	60	2
Air Force	433	108	0	431	109	1

A.7   Contact strategy

A.7.1   Promoting the study

Before the research team made initial direct contact, the following strategies were used to promote the study to participants.

Advertising via print media

The study team developed promotional posters, which were placed in Service newspapers, on DVA and Defence internet and intranet sites, on bases, at ex-service organisations and on the University of Adelaide website.

Ministerial media release

On 11 June 2014 the Hon. Michael Ronaldson, the then Minister for Veterans' Affairs, issued a media release launching the study to the wider community, disseminating information and generating interest among ADF members. The Executive Dean of the Faculty of Health Sciences, members of the Scientific Advisory Committee and members of the investigative team were all present. The launch and media release generated inquiries, which the CTSS research team responded to promptly and effectively, following strict protocol.

Targeted briefs to ADF leadership

Information sessions were held to brief Commanders and other key influencers in the broader Defence community about the importance of the research.

Letter to ex-service organisations

A letter introducing the Transition and Wellbeing Research Programme and an accompanying fact sheet were sent to all relevant ex-service organisations to disseminate information and encourage support for the study.

Distribution of study briefing packs

Briefing packs containing study/promotional materials were distributed to ex-service organisations as another means of promoting the study to the target population.

Social media strategy

A series of social media conversations, promotions and advertisements were rolled out via the Transition and Wellbeing Research Programme's Facebook page (Facebook/aumilresearch) and Twitter account (@aumilresearch) throughout the study period. These accounts were managed by the CTSS research team. The primary objectives of the social media campaign were to raise awareness of the Research Programme among 2015 Regular ADF and Ex-Serving ADF members, their families and their social networks; engage other advocates and key stakeholders; provide another platform for participants to engage with the research team; and disseminate information about previous military research conducted by CTSS.

A.7.2   Development of the Military and Veteran Health Research Study Roll

Participants' contact details and demographic information were obtained from the Military and Veteran Health Research Study Roll, which was created by the AIHW in collaboration with DVA and Defence. This process involved integrating contact information from:

- Defence's PMKeyS database
- DVA client databases
- the National Death Index

- ComSuper's member database
- the MilHOP dataset.

To ensure the information was current and reflected the most recent posting cycles, a final PMKeys download was received immediately before the study began and integrated into the dataset.

This integrated dataset was only passed on to the research team after an opt-out process was conducted. This involved DVA and Defence contacting participants via their websites, email, hard-copy letter, service newspapers and a media campaign and providing them with detailed information about the Study Roll and its broader purpose. The contact information, basic service history and demographic information of individuals who did not opt out of this process within four weeks of the campaign beginning were then passed on to CTSS for the Transition and Wellbeing Research Programme. Participants could still opt out of the Study Roll after the four-week campaign, via an opt-out website or email managed by Defence. This website was open for three months. Individuals who opted out of the Study Roll through this website were excluded from sampling.

To prevent the families of deceased Defence members being approached, the Study Roll was cross-checked against the National Death Index before the opt-out email was sent to individuals and again approximately four weeks before data collection began. All new deaths recorded by Defence were immediately communicated to the research team.

A.7.3   Self-selection procedure

Eligible Ex-Serving members whose details were not passed on to CTSS at the beginning of the study period but who subsequently self-selected into the study were sent to the AIHW for inclusion in the Study Roll. These members were sent an invitation package, following the standard study protocol. Participants Defence deemed ineligible were required to provide proof of their service to CTSS to participate. Reservists who self-selected into the study were only included in the dataset if they appeared on the original Study Roll.

A.7.4   Sampling by data integrator

Before recruitment, the AIHW created samples for the Research Programme, including:

- all members who transitioned from full-time Regular ADF service between 2010 and 2014

- all ADF members who participated in the MilHOP, excluding members who indicated they did not wish to be contacted for further research

- a stratified random sample of 5040 2015 Regular ADF members

- 22,638 currently serving Ab-initio Reservists. (Note that only Reservists with contact information were invited to participate.)

The stratified random sample of 5040 2015 Regular ADF members was drawn from the remainder of members not already listed as MilHOP participants. This sample did not include those who were deceased or who opted out of the Transition and Wellbeing Research Programme.

Stratification was based on:

- Service – Navy, Army, Air Force

- sex

- rank code – Officer/enlistee.

The contact information and demographics for each of the subpopulations listed above, with the exception of individuals who opted out of the Study Roll, were then passed on to CTSS researchers for recruitment and weighting purposes.

A.8   Medicare, PBS and RPBS data linkage

As part of the broader Research Programme, participants were also invited to fill out a consent form authorising the study access to complete Medicare, Pharmaceutical Benefit Scheme and Repatriation Pharmaceutical Benefits Scheme data. Data for each consenting participant were obtained for a five-year period before their scheduled interview date and included information about their medical visits, procedures, associated costs, and prescription medications filled at pharmacies. Consent forms for this component of the research were sent securely to the Department of Human Services, which holds this information confidentially.

A.9   Statistical analysis

This report presents unweighted data. In order to answer the questions of interest, a number of analytical methods were employed. Analyses were performed in SAS version 9.4. For categorical outcomes, n, % and 95% confidence interval are reported. For continuous outcomes, mean and standard error are presented. For each outcome measure, the effect size is estimated with 95% confidence intervals. For continuous outcomes that were assessed at all three time points, repeated measures ANOVAs were conducted to examine whether mean scores significantly changed over time. Where Mauchly's Test of Sphericity showed that the assumption of sphericity was violated, the Greenhouse–Geisser adjusted p value is presented. Statistical significance is assessed at the $p < .05$ level where possible.

For the purposes of this report, responders were defined in a number of ways. Study responders were defined as those individuals who completed any of the study components (survey, CIDI, biological testing, neurocognitive testing, MRI). Responders were further determined for each type of study outcome. Survey responders were defined as those who had completed at least the demographics section of the survey. There were differential response rates for different sections of the survey, so the sample size available for analysis varies according to the outcome being considered and according to the subsample.

For the purpose of analyses, where outcomes are examined longitudinally, data were limited to those individuals with outcomes of interest at all three time points. All results will be presented for the entire cohort (or subsample) and according to whether members of the cohort had transitioned or remained in the Regular ADF in 2015. Where possible, changes over time and between-group differences will be statistically tested, although because of small samples sizes for some outcomes, statistical tests might not be performed, with descriptive data only presented.

A.10   Ethical considerations

In order to combat potential risks and ensure that participation in the study was completely free from coercion, participants were made explicitly aware that their involvement in the study was voluntary and that they could decline to participate and/or were free to withdraw from the project at any time. This was emphasised in all study materials. Second, whether or not an individual chose to participate in the study was not communicated to senior staff in the ADF, nor were members asked directly to participate in the study by a uniformed Officer. This also ensured that recruitment was free from coercion.

In order to manage potential risks to participants in relation to both phase 1 and phase 2 of the research, a duty of care protocol was established and strictly adhered to by the research team.

A.11   Ethical approvals

The study protocol was approved by the DVA Human Research Ethics Committee (E014/017) and was mutually recognised by the Directorate, Defence Health Research, and the University of Adelaide Human Research Ethics Committee. The study protocol was also submitted to the Western Sydney Local Health District Human Research Ethics Committee (4162 AU RED HREC/14/WMEAD/464) and the Australian Institute of Health and Welfare Ethics Committee (EO 2015/1/163) and received approvals accordingly.

Annex B   Detailed tables

B.1   Demographics tables

B.1.1   Demographics of longitudinal sample responders to any component

Table B.1   Demographics of responders to any component by transition status

| | Wave 1: Prospective pre-deployment n = 1914 | | Wave 2: Prospective post-deployment n = 1393 | | Wave 3: Impact of Combat follow-up | | | | | |
| | | | | | Transitioned ADF n = 115 | | 2015 Regular ADF n = 397 | | Total n = 512 | |
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Mean age (SE)		29.4 (0.2)		30.1 (0.2)		36.1 (1.0)		38.2 (0.4)		37.8 (0.4)
Age group										
18–27	1013	52.9 (50.7–55.2)	699	50.2 (47.6–52.8)	30	26.1 (18.1–34.1)	31	7.8 (5.2–10.4)	61	11.9 (9.1–14.7)
28–37	546	28.5 (26.5–30.5)	389	27.9 (25.6–30.3)	46	40.0 (31.0–49.0)	172	43.3 (38.5–48.2)	218	42.6 (38.3–46.9)
38–47	276	14.4 (12.8–16.0)	231	16.6 (14.6–18.5)	19	16.5 (9.7–23.3)	132	33.2 (28.6–37.9)	151	29.5 (25.5–33.4)
48–57	73	3.8 (3.0–4.7)	68	4.9 (3.7–6.0)	10	8.7 (3.5–13.8)	54	13.6 (10.2–17.0)	64	12.5 (9.6–15.4)
58+	6	0.3 (0.1–0.6)	6	0.4 (0.1–0.8)	10	8.7 (3.5–13.8)	8	2.0 (0.6–3.4)	18	3.5 (1.9–5.1)
Service										
Navy	101	5.3 (4.3–6.3)	70	5.0 (3.9–6.2)	3	2.6 (0.0–5.5)	28	7.1 (4.5–9.6)	31	6.1 (4.0–8.1)
Army	1364	71.3 (69.2–73.3)	993	71.3 (68.9–73.7)	100	87.0 (80.8–93.1)	261	65.7 (61.1–70.4)	361	70.5 (66.6–74.5)
Air Force	449	23.5 (21.6–25.4)	330	23.7 (21.5–25.9)	12	10.4 (4.8–16.0)	108	27.2 (22.8–31.6)	120	23.4 (19.8–27.1)
Sex										
Male	1742	91.0 (89.7–92.3)	1266	90.9 (89.4–92.4)	110	95.7 (91.9–99.4)	359	90.4 (87.5–93.3)	469	91.6 (89.2–94.0)
Female	172	9.0 (7.7–10.3)	127	9.1 (7.6–10.6)	5	4.3 (0.6–8.1)	38	9.6 (6.7–12.5)	43	8.4 (6.0–10.8)
Rank										
OFFR	315	16.5 (14.8–18.1)	248	17.8 (15.8–19.8)	10	8.7 (3.5–13.8)	100	25.2 (20.9–29.5)	110	21.5 (17.9–25.0)
NCO	755	39.4 (37.3–41.6)	548	39.3 (36.8–41.9)	62	53.9 (44.8–63.0)	253	63.7 (59.0–68.5)	315	61.5 (57.3–65.7)
Other	844	44.1 (41.9–46.3)	597	42.9 (40.3–45.5)	42	36.5 (27.7–45.3)	42	10.6 (7.6–13.6)	84	16.4 (13.2–19.6)
Missing	0	0.0	0	0.0	1	0.9 (0.0–2.6)	2	0.5 (0.0–1.2)	3	0.6 (0.0–1.2)

Notes: Unweighted data. Response rates presented are calculated as the proportion of those invited to participate in the study.

B.1.2 Demographics of longitudinal sample responders to blood testing

Table B.2 Demographics of blood testing responders by transition status

| | Wave 1: Prospective pre-deployment n = 599 | | Wave 2: Prospective post-deployment n = 348 | | Wave 3: Impact of Combat follow-up | | | | | |
| | | | | | Transitioned ADF n = 6 | | 2015 Regular ADF n = 58 | | Total n = 64 | |
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Mean age (SE)		26.7 (0.3)		26.5 (0.4)		34.5 (3.7)		34.6 (1.1)		34.6 (1.1)
Age group										
18-27	396	66.1 (62.3–69.9)	238	68.4 (63.5–73.3)	3	50.0 (10.0–90.0)	13	22.4 (11.7–33.1)	16	25.0 (14.4–35.6)
28-37	152	25.4 (21.9–28.9)	77	22.1 (17.8–26.5)	0	0.0	27	46.6 (33.7–59.4)	27	42.2 (30.1–54.3)
38-47	45	7.5 (5.4–9.6)	29	8.3 (5.4–11.2)	3	50.0 (10.0–90.0)	12	20.7 (10.3–31.1)	15	23.4 (13.1–33.8)
48-57	6	1.0 (0.2–1.8)	4	1.1 (0.0–2.3)	0	0.0	6	10.3 (2.5–18.2)	6	9.4 (2.2–16.5)
58+	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Service										
Navy	32	5.3 (3.5–7.1)	18	5.2 (2.8–7.5)	0	0.0	3	5.2 (0.0–10.9)	3	4.7 (0.0–9.9)
Army	564	94.2 (92.3–96.0)	330	94.8 (92.5–97.2)	6	100.0 (100.0–100.0)	55	94.8 (89.1–100.0)	61	95.3 (90.1–100.0)
Air Force	3	0.5 (0.0–1.1)	0	0.0	0	0.0	0	0.0	0	0.0
Sex										
Male	589	98.3 (97.3–99.4)	343	98.6 (97.3–99.8)	6	100.0 (100.0–100.0)	56	96.6 (91.9–100.0)	62	96.9 (92.6–100.0)
Female	10	1.7 (0.6–2.7)	5	1.4 (0.2–2.7)	0	0.0	2	3.4 (0.0–8.1)	2	3.1 (0.0–7.4)
Rank										
OFFR	49	8.2 (6.0–10.4)	19	5.5 (3.1–7.8)	0	0.0	5	8.6 (1.4–15.8)	5	7.8 (1.2–14.4)
NCO	204	34.1 (30.3–37.9)	109	31.3 (26.4–36.2)	3	50.0 (10.0–90.0)	39	67.2 (55.2–79.3)	42	65.6 (54.0–77.3)
Other	346	57.8 (53.8–61.7)	220	63.2 (58.2–68.3)	2	33.3 (0.0–71.1)	14	24.1 (13.1–35.2)	16	25.0 (14.4–35.6)
Missing	0	0.0	0	0.0	1	16.7 (0.0–46.5)	0	0.0	1	1.6 (0.0–4.6)

Notes: Unweighted data. Response rates presented are calculated as the proportion of those invited to participate in the study

B.1.3 Demographics of longitudinal sample responders to neurocognitive testing

Table B.3 Demographics of neurocognitive testing responders by transition status

| | Wave 1: Prospective pre-deployment n = 274 | | Wave 2: Prospective post-deployment n = 167 | | Wave 3: Impact of Combat follow-up | | | | | |
| | | | | | Transitioned ADF n = 10 | | 2015 Regular ADF n = 41 | | Total n = 51 | |
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Mean age (SE)		27.9 (0.4)		28.3 (0.5)		31.3 (2.3)		33.9 (1.2)		33.4 (1.1)
Age group										
18-27	157	57.3 (51.4–63.2)	93	55.7 (48.2–63.2)	4	40.0 (9.6–70.4)	8	19.5 (7.4–31.6)	12	23.5 (11.9–35.2)
28-37	86	31.4 (25.9–36.9)	52	31.1 (24.1–38.2)	4	40.0 (9.6–70.4)	23	56.1 (40.9–71.3)	27	52.9 (39.2–66.6)
38-47	29	10.6 (6.9–14.2)	20	12.0 (7.1–16.9)	2	20.0 (0.0–44.8)	6	14.6 (3.8–25.5)	8	15.7 (5.7–25.7)
48-57	2	0.7 (0.0–1.7)	2	1.2 (0.0–2.8)	0	0.0	4	9.8 (0.7–18.8)	4	7.8 (0.5–15.2)
58+	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Service										
Navy	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Army	272	99.3 (98.3–100.0)	167	100.0 (100.0–100.0)	10	100.0 (100.0–100.0)	41	100.0 (100.0–100.0)	51	100.0 (100.0–100.0)
Air Force	2	0.7 (0.0–1.7)	0	0.0	0	0.0	0	0.0	0	0.0
Sex										
Male	269	98.2 (96.6–99.8)	162	97.0 (94.4–99.6)	9	90.0 (71.4–100.0)	38	92.7 (84.7–100.0)	47	92.2 (84.8–99.5)
Female	5	1.8 (0.2–3.4)	5	3.0 (0.4–5.6)	1	10.0 (0.0–28.6)	3	7.3 (0.0–15.3)	4	7.8 (0.5–15.2)
Rank										
OFFR	23	8.4 (5.1–11.7)	9	5.4 (2.0–8.8)	1	10.0 (0.0–28.6)	3	7.3 (0.0–15.3)	4	7.8 (0.5–15.2)
NCO	105	38.3 (32.6–44.1)	68	40.7 (33.3–48.2)	5	50.0 (19.0–81.0)	25	61.0 (46.0–75.9)	30	58.8 (45.3–72.3)
Other	146	53.3 (47.4–59.2)	90	53.9 (46.3–61.5)	3	30.0 (1.6–58.4)	12	29.3 (15.3–43.2)	15	29.4 (16.9–41.9)
Missing	0	0.0	0	0.0	1	10.0 (0.0–28.6)	1	2.4 (0.0–7.2)	2	3.9 (0.0–9.2)

Notes: Unweighted data. Response rates presented are calculated as the proportion of those invited to participate in the study.

B.2   Analytical tables

B.2.1   Biological outcomes for the MEAO Deployed Cohort Time 3 cross-sectional sample

Table B.4   Biological outcomes in the MEAO Deployed Cohort at Time 3

Biological outcomes	Transitioned ADF n = 22			2015 Regular ADF n = 89			Total n = 111		
	n	M	SE	n	M	SE	n	M	SE
Liver enzyme									
Gamma-glutamyl transferase (gamma GT)	22	26.8	4.2	89	20.9	1.1	111	22.1	1.2
Metabolic									
LDL cholesterol	21	3.4	0.2	78	3.1	0.1	99	3.1	0.1
HBA1C - NGSP	22	5.2	0.0	89	5.1	0.0	111	5.1	0.0
Random glucose	22	4.9	0.2	87	4.9	0.1	109	4.9	0.1
Total HDL cholesterol	21	1.3	0.1	78	1.3	0.0	99	1.3	0.0
Triglycerides	21	1.4	0.1	78	1.4	0.1	99	1.4	0.1
Inflammation									
Erythrocyte sedimentation rate (ESR)	21	4.1	1.1	85	2.8	0.2	106	3.1	0.3
White cell count	22	6.3	0.4	86	6.8	0.2	108	6.7	0.2
Interleukin 1b	21	755.6	480.8	84	421.0	212.2	105	487.9	194.5
Interleukin 6	21	695.4	207.2	84	923.4	319.5	105	877.8	258.7
Interleukin 10	21	383.7	202.6	84	588.4	219.1	105	547.5	179.7
TNF alpha	21	2662.0	1331.8	84	2973.3	880.1	105	2911.1	750.3
C-reactive protein (CRP)	22	1.2	0.3	88	1.3	0.2	110	1.3	0.2
Cortisol	21	10421.2	1630.1	84	10523.9	766.3	105	10503.4	690.8
SIL-2RA	21	792.6	94.7	84	789.6	37.1	105	790.2	35.0
Other									
Brain-derived neurotrophic factor (BDNF)	21	33.5	2.4	84	35.0	1.2	105	34.7	1.0

B.2.2 Descriptive outcomes for the MEAO Deployed Cohort at Time 1, 2 and 3, according to psychological distress and posttraumatic stress symptom status at Time 3

Table B.5 Biological outcomes for the MEAO Deployed Cohort at Time 1, 2 and 3, according to psychological distress symptom status at Time 3

Biological outcomes	n	K10 screening cut-off	Time 1 (prospective pre-deployment)		Time 2 (prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
			M	SE	M	SE	M	SE
Liver enzyme								
Gamma-glutamyl transferase (gamma GT)	38	Below screening cut-off	19.9	2.0	24.4	3.7	21.4	1.8
	16	Above screening cut-off	22.3	4.5	24.8	3.7	21.3	2.2
Metabolic								
LDL cholesterol	33	Below screening cut-off	2.6	0.1	2.8	0.1	3.0	0.1
	13	Above screening cut-off	2.8	0.2	2.7	0.2	3.1	0.2
HBA1C - NGSP	38	Below screening cut-off	5.4	0.0	5.3	0.0	5.0	0.0
	16	Above screening cut-off	5.5	0.1	5.3	0.0	5.2	0.1
Random glucose	37	Below screening cut-off	5.1	0.1	5.0	0.1	4.9	0.1
	16	Above screening cut-off	5.2	0.2	5.2	0.2	5.0	0.1
Total HDL cholesterol	34	Below screening cut-off	1.3	0.0	1.3	0.0	1.3	0.0
	13	Above screening cut-off	1.3	0.1	1.3	0.1	1.2	0.1
Triglycerides	34	Below screening cut-off	1.5	0.1	1.4	0.2	1.4	0.1
	13	Above screening cut-off	1.1	0.1	1.5	0.2	1.5	0.3
Inflammation								
Erythrocyte sedimentation rate (ESR)	35	Below screening cut-off	2.4	0.4	2.5	0.5	3.3	0.4
	16	Above screening cut-off	2.8	0.4	2.6	0.6	3.6	0.5
White cell count	37	Below screening cut-off	6.6	0.2	6.8	0.2	6.9	0.3
	16	Above screening cut-off	6.1	0.3	6.4	0.3	6.5	0.4
Interleukin 1b	31	Below screening cut-off	701.6	401.4	600.7	350.0	326.7	213.2
	13	Above screening cut-off	210.2	199.5	72.2	35.0	34.8	16.2
Interleukin 6	32	Below screening cut-off	1340.6	593.6	1489.4	399.7	539.8	196.5
	13	Above screening cut-off	248.3	88.4	757.1	129.2	487.9	97.1
Interleukin 10	32	Below screening cut-off	885.0	359.4	479.0	145.3	402.5	186.1
	13	Above screening cut-off	213.4	70.5	352.2	85.0	211.6	76.1
TNF alpha	32	Below screening cut-off	5623.6	3340.9	7495.5	3235.5	3413.4	1652.0
	13	Above screening cut-off	2371.0	1944.2	2246.3	882.3	1549.9	712.9
C-reactive protein (CRP)	38	Below screening cut-off	0.9	0.3	1.8	0.7	1.2	0.3
	16	Above screening cut-off	0.3	0.2	1.3	0.5	2.0	0.7
Cortisol	32	Below screening cut-off	12849.9	1534.6	13406.2	1433.6	10443.7	1448.4
	14	Above screening cut-off	15893.3	1979.9	12150.8	1575.7	10380.8	1838.0
SIL-2RA	30	Below screening cut-off	1007.7	75.3	905.2	83.2	776.0	56.6
	14	Above screening cut-off	1062.7	96.0	961.0	96.3	791.7	86.3
Other								
Brain-derived neurotrophic factor (BDNF)	29	Below screening cut-off	38.1	1.5	40.1	1.9	35.5	2.4
	13	Above screening cut-off	40.1	3.0	46.2	4.0	34.5	2.6

Table B.6   **Mean number of health symptoms reported by MEAO Deployed Cohort at Time 1, 2 and 3, according to psychological distress symptom status at Time 3**

| | Time 1 (prospective pre-deployment) n = 422 | | Time 2 (prospective post-deployment) n = 422 | | Time 3 (Impact of Combat follow-up) | | | | | |
| | | | | | Transitioned ADF n = 130 | | 2015 Regular ADF n = 292 | | Total n = 422 | |
K10 screening cut-off	M	SE	M	SE	M	SE	M	SE	M	SE
Below screening cut-off	7.0	0.4	8.4	0.5	9.4	0.8	9.5	0.5	9.5	0.4
Above screening cut-off	9.5	0.8	14.9	1.0	23.7	1.6	19.1	1.3	20.5	1.0

Note: Total scores for prospective study only included those with scores on all variables, Impact of Combat had mean scores imputed for missings.

Table B.7   **Mean BMI reported by MEAO Deployed Cohort at Time 1, 2 and 3, according to psychological distress symptom status at Time 3**

| | Time 1 (prospective pre-deployment) = 95 | | Time 2 (prospective post-deployment) n = 95 | | Time 3 (Impact of Combat follow-up) | | | | | |
| | | | | | Transitioned ADF n = 29 | | 2015 Regular ADF n = 66 | | Total n = 95 | |
K10 screening cut-off	M	SE	M	SE	M	SE	M	SE	M	SE
Below screening cut-off	26.2	0.4	26.6	0.4	25.6	0.9	26.6	0.3	26.5	0.3
Above screening cut-off	27.1	0.5	27.8	0.6	26.2	0.8	31.7	2.5	28.7	1.3

Note: Total scores for prospective study only included those with scores on all variables, Impact of Combat had mean scores imputed for missings.

Table B.8   Biological outcomes for the MEAO Deployed Cohort at Time 1, 2 and 3, according to posttraumatic stress symptom status at Time 3

Biological outcomes	n	PCL screening cut-off	Time 1 (prospective pre-deployment)		Time 2 (prospective post-deployment)		Time 3 (Impact of Combat follow-up)	
			M	SE	M	SE	M	SE
Liver enzyme								
Gamma-glutamyl transferase (gamma GT)	34	Below screening cut-off	21.2	2.8	24.7	4.0	20.9	2.0
	17	Above screening cut-off	18.6	2.5	22.8	3.5	21.9	2.1
Metabolic								
LDL cholesterol	31	Below screening cut-off	2.7	0.1	2.8	0.1	3.1	0.1
	13	Above screening cut-off	2.5	0.2	2.6	0.2	2.9	0.2
HBA1C - NGSP	34	Below screening cut-off	5.4	0.0	5.3	0.0	5.1	0.0
	17	Above screening cut-off	5.5	0.0	5.3	0.0	5.2	0.1
Random glucose	33	Below screening cut-off	5.1	0.1	5.0	0.1	4.9	0.1
	17	Above screening cut-off	5.3	0.1	5.0	0.2	5.1	0.1
Total HDL cholesterol	31	Below screening cut-off	1.3	0.1	1.3	0.0	1.3	0.0
	13	Above screening cut-off	1.3	0.1	1.3	0.1	1.2	0.1
Triglycerides	31	Below screening cut-off	1.3	0.1	1.4	0.1	1.4	0.1
	13	Above screening cut-off	1.5	0.2	1.2	0.1	1.5	0.2
Inflammation								
Erythrocyte sedimentation rate (ESR)	32	Below screening cut-off	2.5	0.4	2.7	0.5	3.2	0.4
	16	Above screening cut-off	2.8	0.4	2.4	0.6	4.0	0.6
White cell count	34	Below screening cut-off	6.4	0.2	6.9	0.2	7.0	0.3
	16	Above screening cut-off	6.5	0.3	6.3	0.4	6.2	0.4
Interleukin 1b	29	Below screening cut-off	808.2	433.0	572.5	368.3	339.4	227.6
	13	Above screening cut-off	76.7	60.8	216.2	180.3	56.7	36.3
Interleukin 6	30	Below screening cut-off	1236.5	631.9	1313.9	406.9	585.9	208.3
	13	Above screening cut-off	641.3	256.0	1244.7	372.7	440.5	99.7
Interleukin 10	30	Below screening cut-off	610.6	257.3	387.7	113.9	249.6	59.9
	13	Above screening cut-off	950.4	688.1	612.0	256.9	626.1	445.2
TNF alpha	30	Below screening cut-off	6419.3	3618.8	7462.9	3432.2	3800.1	1751.4
	13	Above screening cut-off	626.2	318.2	2226.6	943.4	1156.8	676.4
C-reactive protein (CRP)	34	Below screening cut-off	0.8	0.3	1.8	0.7	1.4	0.4
	17	Above screening cut-off	0.8	0.4	1.7	0.5	1.9	0.4
Cortisol	30	Below screening cut-off	12566.9	1613.2	12185.8	1230.1	10236.0	1474.6
	14	Above screening cut-off	16990.5	1884.4	14940.0	2413.9	10133.5	1903.6
SIL-2RA	28	Below screening cut-off	1002.1	79.7	915.1	85.3	766.4	59.9
	14	Above screening cut-off	1110.2	91.2	973.1	107.0	830.6	86.2
Other								
Brain-derived neurotrophic factor (BDNF)	28	Below screening cut-off	38.2	1.5	40.0	1.9	36.8	2.4
	12	Above screening cut-off	40.4	3.3	47.1	4.3	33.3	2.9

Table B.9 **Mean number of health symptoms reported by MEAO Deployed Cohort at Time 1, 2 and 3, according to posttraumatic stress symptom status at Time 3**

| | Time 1 (prospective pre-deployment) n = 421 | | Time 2 (prospective post-deployment) n = 421 | | Time 3 (Impact of Combat follow-up) | | | | | |
| | | | | | Transitioned ADF n = 117 | | 2015 Regular ADF n = 304 | | Total n = 421 | |
PCL screening cut-off	M	SE	M	SE	M	SE	M	SE	M	SE
Below screening cut-off	6.7	0.4	8.0	0.4	10.3	1.0	9.1	0.5	9.3	0.4
Above screening cut-off	10.5	0.9	16.6	1.1	23.4	1.6	21.8	1.3	22.4	1.0

Note: Total scores for prospective study only included those with scores on all variables, Impact of Combat had mean scores imputed for missings.

Table B.10 **Mean BMI reported by MEAO Deployed Cohort at Time 1, 2 and 3, according to posttraumatic stress symptom status at Time 3**

| | Time 1 (prospective pre-deployment) n = 94 | | Time 2 (prospective post-deployment) n = 94 | | Time 3 (Impact of Combat follow-up) | | | | | |
| | | | | | Transitioned ADF n = 32 | | 2015 Regular ADF n = 62 | | Total n = 94 | |
PCL screening cut-off	M	SE	M	SE	M	SE	M	SE	M	SE
Below screening cut-off	26.3	0.4	26.7	0.4	25.7	0.9	26.7	0.3	26.6	0.3
Above screening cut-off	26.6	0.5	27.3	0.5	26.2	0.8	30.2	2.2	28.2	1.2

Note: Total scores for prospective study only included those with scores on all variables, Impact of Combat had mean scores imputed for missings.

Table B.11   Odds ratios for univariate predictors of psychological distress symptom status at Time 3 in the MEAO Deployed Cohort

Results table	Predictor	Comparison	Adjusted OR (95% CI)	p value
Demographic and service characteristics (Time 1)				
Table 5.1	Age	-	0.98 (0.96–1.01)	ns
	Sex	Male vs female (ref)	1.78 (0.71–4.50)	ns
	Rank	NCO vs OFFR (ref)	1.57 (0.83–2.99)	ns
		Other vs OFFR (ref)	2.54 (1.26–5.12)	0.0093
		NCO vs other (ref)	0.62 (0.36–1.08)	ns
	Service	Army vs Air Force (ref)	1.78 (1.00–3.17)	0.0492
		Navy vs Air Force (ref)	1.38 (0.43–4.36)	ns
		Army vs Navy (ref)	1.30 (0.44–3.80)	ns
	Length of service	-	0.97 (0.94–1.00)	ns
	Number of deployments	-	1.10 (1.01–1.19)	0.0316
	Deployment experience	Ever vs never (ref)	1.36 (0.79–2.33)	ns
	Number lifetime trauma types	-	1.10 (1.00–1.21)	ns
Self-reported military career deployment exposures, anger and mean psychological distress				
Table 5.2	Traumatic deployment exposures (Time 3)	-	1.04 (1.02–1.06)	0.0002
		Low vs very low (ref)	1.29 (0.56–2.98)	ns
		Medium vs very low (ref)	1.43 (0.62–3.32)	ns
		High vs very low (ref)	3.18 (1.41–7.15)	0.0052
		Very high vs very low (ref)	3.26 (1.46–7.24)	0.0038
	Environmental deployment exposures (Time 3)	-	1.03 (0.99–1.08)	ns
		Medium vs low (ref)	0.85 (0.42–1.74)	ns
		High vs low (ref)	1.10 (0.59–2.06)	ns
		Very high vs low (ref)	2.00 (1.00–4.01)	ns
	Anger (DAR-5) problematic anger (Time 1)	Yes vs no (ref)	1.46 (0.49–4.37)	ns
	Anger (DAR-5) problematic anger (Time 2)	Yes vs no (ref)	2.92 (1.36–6.26)	0.0059
	Psychological distress (K10) (Time 1)	-	1.09 (1.03–1.16)	0.002
	Psychological distress (K10) (Time 2)	-	1.14 (1.08–1.20)	<0.0001

Ns – Not significant.

Table B.12   Odds ratios for univariate predictors of posttraumatic stress symptom status at Time 3 in the MEAO Deployed Cohort

Results table	Predictor	Comparison	Adjusted OR (95% CI)	p value
Demographic and service characteristics (Time 1)				
Table 5.4	Age	-	1.00 (0.98–1.03)	ns
	Sex	Male vs female (ref)	4.26 (1.14–15.95)	0.0313
	Rank	NCO vs OFFR (ref)	1.90 (0.92–3.89)	ns
		Other vs OFFR (ref)	2.56 (1.17–5.59)	0.0183
		NCO vs other (ref)	0.74 (0.41–1.35)	ns
	Service	Army vs Air Force (ref)	2.21 (1.13–4.31)	0.0199
		Navy vs Air Force (ref)	1.25 (0.31–5.10)	ns
		Army vs Navy (ref)	1.76 (0.48–6.47)	ns
	Length of service	-	1.01 (0.98–1.04)	ns
	Number of deployments	-	1.02 (0.93–1.12)	ns
	Deployment experience	Ever vs never (ref)	1.56 (0.85–2.89)	ns
	Number lifetime trauma types	-	1.22 (1.10–1.36)	0.0003
Self-reported career deployment exposures, anger and mean posttraumatic stress symptoms				
Table 5.5	Traumatic deployment exposures (Time 3)	-	1.05 (1.03–1.08)	<0.0001
		Low vs very low (ref)	0.79 (0.26–2.42)	ns
		Medium vs very low (ref)	2.58 (0.98–6.79)	ns
		High vs very low (ref)	4.27 (1.63–11.19)	0.0032
		Very high vs very low (ref)	4.29 (1.65–11.16)	0.0029
	Environmental deployment exposures (Time 3)	-	1.10 (1.04–1.16)	0.0003
		Medium vs low (ref)	1.02 (0.42–2.47)	ns
		High vs low (ref)	2.38 (1.14–4.95)	0.0203
		Very high vs low (ref)	4.10 (1.85–9.12)	0.0005
	Anger (DAR-5) problematic anger (Time 1)	Yes vs no (ref)	0.80 (0.22–2.88)	ns
	Anger (DAR-5) problematic anger (Time 2)	Yes vs no (ref)	2.67 (1.16–6.18)	0.0213
	Posttraumatic stress symptoms (PCL-C) (Time 1)	-	1.12 (1.07–1.18)	<0.0001
	Posttraumatic stress symptoms (PCL-C) (Time 2)	-	1.12 (1.08–1.17)	<0.0001

Ns – Not significant.

Annex C   Pilot neuroimaging investigation: detailed tables

C.1   Associations between cortical volumes and psychological, exposure and cognitive indices

		Volume (mm³)	Left Caudal Anterior Cingulate	Left Caudal Middle Frontal	Left Cuneus	Left Entorhinal
Exposure score	Pearson Correlation	0.211	0.105	−0.279	−0.147	0.064
	Sig. (2-tailed)	0.255	0.575	0.129	0.431	0.731
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.344	−0.222	−0.177	−0.130	0.235
	Sig. (2-tailed)	0.099	0.297	0.409	0.545	0.269
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.234	−0.189	−0.098	−0.327	0.343
	Sig. (2-tailed)	0.307	0.411	0.672	0.148	0.128
	n	21	21	21	21	21
K10	Pearson Correlation	0.033	0.176	−0.044	−0.007	−.408
	Sig. (2-tailed)	0.861	0.343	0.815	0.969	0.023
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.108	0.119	−0.065	0.171	−.410
	Sig. (2-tailed)	0.562	0.523	0.727	0.358	0.022
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.375	−0.007	0.252	−0.116	−0.096
	Sig. (2-tailed)	0.054	0.971	0.204	0.563	0.635
	n	27	27	27	27	27
	Sig. (2-tailed)	0.894	0.052	0.817	0.550	0.374
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.150	−0.269	0.054	0.097	0.134
	Sig. (2-tailed)	0.413	0.137	0.769	0.597	0.464
	n	32	32	32	32	32

		Left Fusiform	Left Inferior Parietal	Left Inferior Temporal	Left Isthmus Cingulate	Left Lateral Occipital
Exposure score	Pearson Correlation	−0.054	−0.121	−0.206	−0.270	−0.164
	Sig. (2-tailed)	0.773	0.518	0.267	0.142	0.377
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.304	−0.119	−0.106	−0.037	−0.110
	Sig. (2-tailed)	0.149	0.580	0.622	0.863	0.609
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.129	0.258	0.085	−0.105	−0.174
	Sig. (2-tailed)	0.576	0.259	0.715	0.652	0.450
	n	21	21	21	21	21
K10	Pearson Correlation	−0.008	−0.102	0.069	0.139	−0.045
	Sig. (2-tailed)	0.964	0.584	0.712	0.457	0.809
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.021	0.046	−0.013	0.046	0.098
	Sig. (2-tailed)	0.910	0.808	0.946	0.807	0.599
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.143	0.018	0.124	−0.154	−0.306
	Sig. (2-tailed)	0.478	0.927	0.537	0.442	0.121
	n	27	27	27	27	27
	Sig. (2-tailed)	0.289	0.983	0.861	0.660	0.773
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.158	0.128	0.181	−0.010	0.052
	Sig. (2-tailed)	0.388	0.484	0.320	0.958	0.778
	n	32	32	32	32	32

		Left Lateral Orbitofrontal	Left Lingual	Left Medial Orbitofrontal	Left Middle Temporal	Left Parahippo-campal
Exposure score	Pearson Correlation	−0.135	−0.045	−0.062	−0.005	0.139
	Sig. (2-tailed)	0.468	0.810	0.740	0.979	0.457
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.343	0.013	−.447	−.459	−0.111
	Sig. (2-tailed)	0.100	0.951	0.029	0.024	0.606
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.068	−0.182	−0.165	0.247	0.095
	Sig. (2-tailed)	0.770	0.429	0.473	0.281	0.681
	n	21	21	21	21	21
K10	Pearson Correlation	−0.002	−0.040	−0.070	0.061	−0.266
	Sig. (2-tailed)	0.991	0.832	0.709	0.745	0.147
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.162	−0.012	0.034	−0.017	−0.206
	Sig. (2-tailed)	0.385	0.950	0.856	0.928	0.266
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.260	−.416	−0.040	0.180	−0.045
	Sig. (2-tailed)	0.191	0.031	0.844	0.368	0.822
	n	27	27	27	27	27
	Sig. (2-tailed)	0.290	0.459	0.166	0.421	0.448
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.009	−0.044	−0.058	0.058	−0.085
	Sig. (2-tailed)	0.961	0.811	0.754	0.751	0.642
	n	32	32	32	32	32

		Left Paracentral	Left Pars Opercularis	Left Pars Orbitalis	Left Pars Triangularis	Left Peri Calcarine
Exposure score	Pearson Correlation	−0.260	−0.089	−0.143	−0.071	−0.189
	Sig. (2-tailed)	0.158	0.633	0.444	0.705	0.308
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.067	−0.041	−.456	−.417	−0.050
	Sig. (2-tailed)	0.756	0.849	0.025	0.043	0.818
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.219	−0.143	−0.094	−0.092	−.445
	Sig. (2-tailed)	0.340	0.536	0.684	0.690	0.043
	n	21	21	21	21	21
K10	Pearson Correlation	−0.085	0.285	−0.019	0.110	−0.095
	Sig. (2-tailed)	0.648	0.120	0.920	0.557	0.612
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.061	0.183	0.093	0.157	0.148
	Sig. (2-tailed)	0.744	0.324	0.618	0.399	0.426
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.202	−0.057	−0.017	0.028	−0.183
	Sig. (2-tailed)	0.312	0.776	0.933	0.889	0.360
	n	27	27	27	27	27
	Sig. (2-tailed)	0.611	0.956	0.846	0.039	0.759
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.074	0.251	0.103	0.169	−0.003
	Sig. (2-tailed)	0.689	0.165	0.576	0.354	0.989
	n	32	32	32	32	32

		Left Postcentral	Left Posterior Cingulate	Left Precentral	Left Precuneus	Left Rostral Anterior Cingulate
Exposure score	Pearson Correlation	−0.078	−0.134	−0.341	−0.246	0.106
	Sig. (2-tailed)	0.676	0.472	0.061	0.183	0.571
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.156	−0.102	−0.388	−0.139	−0.133
	Sig. (2-tailed)	0.466	0.634	0.061	0.517	0.537
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.017	0.019	−0.186	−0.133	−0.031
	Sig. (2-tailed)	0.940	0.935	0.419	0.566	0.895
	n	21	21	21	21	21
K10	Pearson Correlation	0.221	−0.034	0.070	0.003	0.087
	Sig. (2-tailed)	0.233	0.855	0.710	0.987	0.640
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.159	0.111	0.117	−0.048	0.048
	Sig. (2-tailed)	0.392	0.552	0.530	0.796	0.798
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.032	0.025	0.032	0.178	0.202
	Sig. (2-tailed)	0.875	0.900	0.872	0.375	0.312
	n	27	27	27	27	27
	Sig. (2-tailed)	0.728	0.682	0.788	0.646	0.843
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.054	0.006	−0.297	−0.030	−0.022
	Sig. (2-tailed)	0.768	0.975	0.099	0.870	0.903
	n	32	32	32	32	32

		Left Rostral Middle Frontal	Left Superior Frontal	Left Superior Parietal	Left Superior Temporal	Left Supra-marginal
Exposure score	Pearson Correlation	0.038	−0.264	−0.211	−0.121	−0.147
	Sig. (2-tailed)	0.839	0.151	0.256	0.515	0.429
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.329	−0.277	−0.331	−0.363	−0.328
	Sig. (2-tailed)	0.116	0.190	0.114	0.082	0.117
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.073	−0.158	−0.128	−0.056	−0.257
	Sig. (2-tailed)	0.753	0.494	0.580	0.810	0.261
	n	21	21	21	21	21
K10	Pearson Correlation	0.029	0.224	0.143	0.216	0.187
	Sig. (2-tailed)	0.876	0.225	0.443	0.242	0.313
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.138	0.207	0.110	0.127	0.221
	Sig. (2-tailed)	0.459	0.265	0.557	0.495	0.231
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.099	0.139	−0.017	−0.026	0.253
	Sig. (2-tailed)	0.624	0.490	0.932	0.898	0.202
	n	27	27	27	27	27
	Sig. (2-tailed)	0.176	0.515	0.651	0.226	0.783
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.022	−0.140	−0.109	0.099	−0.147
	Sig. (2-tailed)	0.904	0.444	0.551	0.590	0.422
	n	32	32	32	32	32

		Left Frontal Pole	Left Temporal Pole	Left Transverse Temporal	Left Insula	Right Bankssts vol avg
Exposure score	Pearson Correlation	−0.202	−0.284	0.053	−0.070	−0.175
	Sig. (2-tailed)	0.277	0.122	0.777	0.710	0.347
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.286	−0.191	−0.391	−0.353	−.495
	Sig. (2-tailed)	0.176	0.372	0.059	0.090	0.014
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.073	0.048	0.120	−0.193	0.050
	Sig. (2-tailed)	0.753	0.836	0.604	0.403	0.830
	n	21	21	21	21	21
K10	Pearson Correlation	−0.100	−0.293	0.074	0.035	0.122
	Sig. (2-tailed)	0.593	0.110	0.693	0.850	0.513
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.064	−0.125	0.116	0.092	0.090
	Sig. (2-tailed)	0.731	0.503	0.535	0.621	0.629
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.044	0.140	0.126	0.168	−0.088
	Sig. (2-tailed)	0.827	0.487	0.533	0.402	0.662
	n	27	27	27	27	27
	Sig. (2-tailed)	0.052	0.781	0.177	0.588	0.500
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.033	0.114	0.141	0.085	−0.257
	Sig. (2-tailed)	0.859	0.536	0.442	0.642	0.156
	n	32	32	32	32	32

		Right Caudal Anterior Cingulate	Right Caudal Middle Frontal	Right Cuneus	Right Entorhinal	Right Fusiform
Exposure score	Pearson Correlation	–0.149	0.124	–0.115	0.077	–0.110
	Sig. (2-tailed)	0.423	0.507	0.538	0.679	0.555
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	–0.074	–0.289	–0.047	0.008	–0.168
	Sig. (2-tailed)	0.733	0.171	0.829	0.970	0.433
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	–0.015	0.126	–0.258	0.234	0.144
	Sig. (2-tailed)	0.948	0.587	0.259	0.308	0.534
	n	21	21	21	21	21
K10	Pearson Correlation	0.135	0.234	0.155	–0.240	0.032
	Sig. (2-tailed)	0.470	0.205	0.407	0.194	0.864
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.061	.422	0.273	–0.005	0.036
	Sig. (2-tailed)	0.745	0.018	0.137	0.980	0.849
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	–0.082	0.145	–0.230	–0.006	–0.054
	Sig. (2-tailed)	0.683	0.470	0.249	0.977	0.790
	n	27	27	27	27	27
	Sig. (2-tailed)	0.644	0.433	0.299	0.914	0.390
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.237	0.029	–0.002	0.298	0.122
	Sig. (2-tailed)	0.192	0.873	0.992	0.097	0.505
	n	32	32	32	32	32

		Right Inferior Parietal	Right Inferior Temporal	Right Isthmus Cingulate	Right Lateral Occipital	Right Lateral Orbitofrontal
Exposure score	Pearson Correlation	−0.018	−0.287	−0.234	−0.267	−0.128
	Sig. (2-tailed)	0.925	0.118	0.206	0.146	0.492
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.376	−0.351	−0.116	−0.033	−0.256
	Sig. (2-tailed)	0.070	0.092	0.590	0.878	0.227
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.031	0.231	0.119	0.003	0.036
	Sig. (2-tailed)	0.894	0.314	0.606	0.989	0.877
	n	21	21	21	21	21
K10	Pearson Correlation	0.321	0.094	−0.064	−0.048	0.026
	Sig. (2-tailed)	0.079	0.614	0.733	0.796	0.889
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.327	0.043	0.009	−0.069	0.137
	Sig. (2-tailed)	0.073	0.818	0.962	0.712	0.463
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.367	−0.084	−0.013	0.051	0.139
	Sig. (2-tailed)	0.060	0.678	0.947	0.802	0.488
	n	27	27	27	27	27
	Sig. (2-tailed)	0.243	0.595	0.383	0.774	0.159
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.163	0.058	−0.125	−0.090	0.034
	Sig. (2-tailed)	0.371	0.752	0.495	0.624	0.854
	n	32	32	32	32	32

		Right Lingual	Right Medial Orbitofrontal	Right Middle Temporal	Right Parahippocampal	Right Paracentral
Exposure score	Pearson Correlation	–0.195	–0.141	–0.074	0.337	–0.128
	Sig. (2-tailed)	0.294	0.449	0.694	0.063	0.494
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	–0.288	0.049	–0.308	0.057	–0.154
	Sig. (2-tailed)	0.172	0.821	0.144	0.792	0.473
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	–0.111	–0.140	–0.012	–0.137	–0.248
	Sig. (2-tailed)	0.633	0.544	0.958	0.553	0.278
	n	21	21	21	21	21
K10	Pearson Correlation	0.121	–0.114	–0.087	–0.145	0.153
	Sig. (2-tailed)	0.516	0.542	0.641	0.438	0.410
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.163	–0.107	0.047	–0.143	0.108
	Sig. (2-tailed)	0.381	0.565	0.801	0.442	0.564
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.093	0.228	–0.028	0.054	0.073
	Sig. (2-tailed)	0.644	0.252	0.891	0.787	0.719
	n	27	27	27	27	27
	Sig. (2-tailed)	0.013	0.359	0.643	0.372	0.589
	n	34	34	34	34	34
Working memory	Pearson Correlation	–0.002	0.000	0.180	0.127	0.045
	Sig. (2-tailed)	0.992	1.000	0.323	0.487	0.805
	n	32	32	32	32	32

		Right Pars Opercularis	Right Pars Orbitalis	Right Pars Triangularis	Right Pericalcarine	Right Postcentral
Exposure score	Pearson Correlation	–0.209	–0.024	0.085	–0.146	–0.302
	Sig. (2-tailed)	0.260	0.899	0.648	0.432	0.099
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	–0.354	–0.329	–0.339	–0.344	–0.304
	Sig. (2-tailed)	0.090	0.116	0.106	0.100	0.149
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	–0.061	–0.011	–0.336	–.521	–0.064
	Sig. (2-tailed)	0.793	0.962	0.136	0.015	0.782
	n	21	21	21	21	21
K10	Pearson Correlation	0.108	–0.053	0.085	–0.110	0.114
	Sig. (2-tailed)	0.563	0.777	0.650	0.557	0.542
	n	31	31	31	31	31
PCL-C	Pearson Correlation	–0.031	–0.041	0.086	–0.039	0.149
	Sig. (2-tailed)	0.869	0.829	0.644	0.837	0.422
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	–0.046	–0.030	0.064	–0.100	–0.064
	Sig. (2-tailed)	0.820	0.880	0.750	0.621	0.751
	n	27	27	27	27	27
	Sig. (2-tailed)	0.769	0.380	0.827	0.266	0.132
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.049	–0.021	–0.035	–0.249	–0.050
	Sig. (2-tailed)	0.790	0.908	0.849	0.170	0.785
	n	32	32	32	32	32

		Right Posterior Cingulate	Right Precentral	Right Precuneus	Right Rostral Anterior Cingulate	Right Rostral Middle Frontal
Exposure score	Pearson Correlation	−0.189	−0.064	−0.299	0.007	−0.118
	Sig. (2-tailed)	0.308	0.733	0.102	0.970	0.526
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.193	−0.040	−0.235	−0.387	−0.334
	Sig. (2-tailed)	0.367	0.854	0.269	0.062	0.111
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.105	0.000	−0.138	0.176	−0.123
	Sig. (2-tailed)	0.650	1.000	0.551	0.447	0.596
	n	21	21	21	21	21
K10	Pearson Correlation	0.132	−0.029	0.017	0.202	−0.054
	Sig. (2-tailed)	0.479	0.879	0.928	0.275	0.772
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.061	0.085	0.087	0.284	0.009
	Sig. (2-tailed)	0.744	0.648	0.641	0.122	0.963
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.020	−0.097	0.126	0.056	0.261
	Sig. (2-tailed)	0.920	0.629	0.531	0.781	0.189
	n	27	27	27	27	27
	Sig. (2-tailed)	0.793	0.089	0.543	0.065	0.467
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.115	0.029	−0.005	0.119	−0.092
	Sig. (2-tailed)	0.531	0.874	0.980	0.518	0.617
	n	32	32	32	32	32

		Right Superior Frontal	Right Superior Parietal	Right Superior Temporal	Right Supramarginal
Exposure score	Pearson Correlation	−0.032	−0.187	−0.188	−0.218
	Sig. (2-tailed)	0.866	0.313	0.311	0.239
	n	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.284	−0.190	−0.381	−0.231
	Sig. (2-tailed)	0.179	0.375	0.066	0.278
	n	24	24	24	24
Number of TBIs	Pearson Correlation	0.084	0.128	0.022	−0.042
	Sig. (2-tailed)	0.716	0.582	0.926	0.857
	n	21	21	21	21
K10	Pearson Correlation	0.151	0.091	0.261	−0.081
	Sig. (2-tailed)	0.416	0.627	0.156	0.663
	n	31	31	31	31
PCL-C	Pearson Correlation	0.210	0.204	0.264	−0.217
	Sig. (2-tailed)	0.258	0.272	0.152	0.242
	n	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.064	−0.094	0.053	−0.176
	Sig. (2-tailed)	0.750	0.639	0.794	0.380
	n	27	27	27	27
	Sig. (2-tailed)	0.176	0.525	0.293	0.638
	n	34	34	34	34
Working memory	Pearson Correlation	−0.113	0.282	0.056	−0.060
	Sig. (2-tailed)	0.539	0.117	0.762	0.742
	n	32	32	32	32

		Right Frontal Pole	Right Temporal Pole	Right Transverse Temporal	Right insula
Exposure score	Pearson Correlation	−0.275	0.076	−0.118	−0.168
	Sig. (2-tailed)	0.134	0.685	0.526	0.365
	n	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.153	−0.284	−0.141	−0.263
	Sig. (2-tailed)	0.474	0.178	0.513	0.215
	n	24	24	24	24
Number of TBIs	Pearson Correlation	0.018	0.135	−0.003	−.472
	Sig. (2-tailed)	0.940	0.559	0.991	0.031
	n	21	21	21	21
K10	Pearson Correlation	0.115	0.017	−0.012	0.179
	Sig. (2-tailed)	0.539	0.927	0.948	0.335
	n	31	31	31	31
PCL-C	Pearson Correlation	−0.025	0.190	−0.067	0.158
	Sig. (2-tailed)	0.894	0.306	0.721	0.395
	n	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.137	−0.267	0.003	−0.032
	Sig. (2-tailed)	0.496	0.178	0.987	0.874
	n	27	27	27	27
	Sig. (2-tailed)	0.714	0.796	0.217	0.596
	n	34	34	34	34
Working memory	Pearson Correlation	−0.003	.439	−0.130	−0.027
	Sig. (2-tailed)	0.987	0.012	0.480	0.883
	n	32	32	32	32

C.2 Associations between sub-cortical volumes and psychological, exposure and cognitive indices

		Sub-cortical volumes (mm³)	L_caud	L_put	L_pal	L_hippo
Exposure score	Pearson Correlation	0.166	0.064	−0.138	−0.044	0.127
	Sig. (2-tailed)	0.372	0.734	0.460	0.816	0.495
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.216	−0.372	0.030	0.319	0.186
	Sig. (2-tailed)	0.310	0.074	0.889	0.129	0.383
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.022	−0.005	0.083	0.279	−0.081
	Sig. (2-tailed)	0.924	0.982	0.721	0.221	0.726
	n	21	21	21	21	21
K10	Pearson Correlation	0.238	0.130	−0.076	0.001	−0.200
	Sig. (2-tailed)	0.196	0.486	0.683	0.998	0.280
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.196	0.140	−0.043	0.024	−0.178
	Sig. (2-tailed)	0.290	0.452	0.817	0.896	0.339
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.144	.391	0.050	0.003	0.183
	Sig. (2-tailed)	0.473	0.044	0.806	0.989	0.360
	n	27	27	27	27	27
	Sig. (2-tailed)	0.409	0.483	0.377	0.732	0.344
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.203	−0.229	−0.021	0.111	0.145
	Sig. (2-tailed)	0.265	0.207	0.909	0.546	0.429

C.3 Associations between cortical thickness and psychological, exposure and cognitive indices

		Cortical thickness (mm)	Left Caudal Anterior Cingulate	Left Caudal Middle Frontal	Left Cuneus	Left Entorhinal
Exposure score	Pearson Correlation	0.130	–0.083	–0.109	–0.227	–0.186
	Sig. (2-tailed)	0.487	0.657	0.559	0.220	0.316
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	–0.047	0.102	–0.072	–0.065	–0.331
	Sig. (2-tailed)	0.828	0.635	0.739	0.764	0.114
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.152	–0.117	0.192	–0.291	0.047
	Sig. (2-tailed)	0.509	0.615	0.405	0.200	0.839
	n	21	21	21	21	21
K10	Pearson Correlation	–0.019	0.006	–0.030	–0.028	0.177
	Sig. (2-tailed)	0.917	0.973	0.871	0.882	0.340
	n	31	31	31	31	31
PCL-C	Pearson Correlation	–0.097	0.092	0.001	0.237	0.099
	Sig. (2-tailed)	0.605	0.624	0.994	0.200	0.595
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.030	–0.285	0.211	–0.301	0.055
	Sig. (2-tailed)	0.880	0.149	0.292	0.127	0.784
	n	27	27	27	27	27
	Sig. (2-tailed)	0.974	0.537	0.889	0.561	0.319
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.103	–0.191	–0.029	0.283	–.391
	Sig. (2-tailed)	0.574	0.296	0.874	0.116	0.027
	n	32	32	32	32	32

		Left Fusiform	Left Inferior Parietal	Left Inferior Temporal	Left Isthmus Cingulate	Left Lateral Occipital
Exposure score	Pearson Correlation	−0.219	−0.161	0.036	−.388	−0.143
	Sig. (2-tailed)	0.236	0.387	0.848	0.031	0.444
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.308	−0.242	−0.079	−0.152	−0.238
	Sig. (2-tailed)	0.143	0.254	0.713	0.479	0.263
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.211	−0.059	−0.064	0.218	−0.316
	Sig. (2-tailed)	0.359	0.801	0.782	0.343	0.163
	n	21	21	21	21	21
K10	Pearson Correlation	−0.248	−0.257	−0.162	−0.127	0.093
	Sig. (2-tailed)	0.178	0.162	0.384	0.495	0.618
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.175	−0.120	−0.058	−0.038	0.225
	Sig. (2-tailed)	0.345	0.522	0.755	0.839	0.223
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.146	−0.134	0.087	0.025	−0.253
	Sig. (2-tailed)	0.466	0.506	0.666	0.903	0.203
	n	27	27	27	27	27
	Sig. (2-tailed)	0.102	0.818	0.791	0.474	0.782
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.114	0.220	0.188	−0.010	−0.001
	Sig. (2-tailed)	0.534	0.226	0.303	0.958	0.996
	n	32	32	32	32	32

		Left Lateral Orbitofrontal	Left Lingual	Left Medial Orbitofrontal	Left Middle Temporal	Left Parahippo-campal
Exposure score	Pearson Correlation	0.037	−0.201	−0.026	0.244	0.239
	Sig. (2-tailed)	0.842	0.279	0.892	0.186	0.196
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−.494	−0.167	−0.125	−0.338	0.182
	Sig. (2-tailed)	0.014	0.435	0.560	0.107	0.395
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.090	−0.124	−0.062	0.085	0.205
	Sig. (2-tailed)	0.697	0.592	0.791	0.715	0.372
	n	21	21	21	21	21
K10	Pearson Correlation	−0.018	−0.133	−0.039	−0.161	−0.215
	Sig. (2-tailed)	0.924	0.477	0.834	0.387	0.245
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.001	−0.152	0.140	−0.096	−0.290
	Sig. (2-tailed)	0.997	0.416	0.454	0.607	0.113
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−.419	−0.284	−0.143	0.055	−0.208
	Sig. (2-tailed)	0.030	0.151	0.476	0.787	0.297
	n	27	27	27	27	27
	Sig. (2-tailed)	0.799	0.511	0.572	0.068	0.888
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.083	0.107	−0.040	−0.026	−0.045
	Sig. (2-tailed)	0.651	0.560	0.826	0.887	0.808
	n	32	32	32	32	32

		Left Paracentral	Left Pars Opercularis	Left Pars Orbitalis	Left Pars Triangularis	Left Peri Calcarine
Exposure score	Pearson Correlation	−0.254	0.204	−0.268	−0.281	−0.264
	Sig. (2-tailed)	0.169	0.272	0.145	0.125	0.152
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.161	−0.377	−0.278	−0.206	−0.241
	Sig. (2-tailed)	0.451	0.069	0.188	0.335	0.257
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.408	−0.368	0.431	0.086	−0.028
	Sig. (2-tailed)	0.066	0.101	0.051	0.710	0.903
	n	21	21	21	21	21
K10	Pearson Correlation	−0.262	0.296	−0.198	−0.148	0.038
	Sig. (2-tailed)	0.154	0.106	0.285	0.428	0.838
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.067	0.287	−0.076	−0.090	0.207
	Sig. (2-tailed)	0.721	0.118	0.686	0.629	0.265
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.080	.395	−0.223	−0.056	−0.254
	Sig. (2-tailed)	0.691	0.041	0.265	0.781	0.201
	n	27	27	27	27	27
	Sig. (2-tailed)	0.030	0.989	0.594	0.105	0.799
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.190	0.002	−0.014	0.117	0.213
	Sig. (2-tailed)	0.298	0.993	0.940	0.522	0.242
	n	32	32	32	32	32

		Left Postcentral	Left Posterior Cingulate	Left Precentral	Left Precuneus	Left Rostral Anterior Cingulate
Exposure score	Pearson Correlation	−0.058	−0.248	−0.043	−0.301	−0.009
	Sig. (2-tailed)	0.755	0.179	0.817	0.099	0.960
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.297	0.010	−0.699**	−0.006	−0.095
	Sig. (2-tailed)	0.159	0.963	0.000	0.978	0.660
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.039	0.227	−0.121	−0.176	−0.316
	Sig. (2-tailed)	0.867	0.323	0.602	0.446	0.162
	n	21	21	21	21	21
K10	Pearson Correlation	0.236	−0.183	0.136	−0.198	0.012
	Sig. (2-tailed)	0.201	0.324	0.466	0.285	0.948
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.340	−0.109	0.156	−0.114	0.022
	Sig. (2-tailed)	0.061	0.560	0.403	0.543	0.908
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.264	0.112	0.169	−0.010	−0.011
	Sig. (2-tailed)	0.182	0.578	0.399	0.960	0.955
	n	27	27	27	27	27
	Sig. (2-tailed)	0.379	0.387	0.262	0.362	0.395
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.110	−0.256	−.381	0.131	−0.128
	Sig. (2-tailed)	0.548	0.158	0.032	0.473	0.486
	n	32	32	32	32	32

		Left Rostral Middle Frontal	Left Superior Frontal	Left Superior Parietal	Left Superior Temporal	Left Supra-marginal
Exposure score	Pearson Correlation	−0.100	−.432	−0.214	−0.009	−0.094
	Sig. (2-tailed)	0.592	0.015	0.247	0.963	0.615
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.188	−0.337	−0.238	−0.291	−0.256
	Sig. (2-tailed)	0.378	0.107	0.263	0.167	0.228
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.013	0.030	−0.172	0.270	−0.125
	Sig. (2-tailed)	0.954	0.897	0.457	0.237	0.590
	n	21	21	21	21	21
K10	Pearson Correlation	−0.328	−0.235	−0.103	−0.174	0.067
	Sig. (2-tailed)	0.072	0.203	0.583	0.349	0.719
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.302	−0.191	0.009	−0.086	0.006
	Sig. (2-tailed)	0.099	0.303	0.964	0.644	0.973
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.068	−0.247	−0.276	−0.105	0.053
	Sig. (2-tailed)	0.738	0.215	0.163	0.604	0.793
	n	27	27	27	27	27
	Sig. (2-tailed)	0.790	0.372	0.980	0.202	0.046
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.203	−0.099	−0.012	0.221	−0.033
	Sig. (2-tailed)	0.265	0.589	0.948	0.224	0.859
	n	32	32	32	32	32

		Left Frontal Pole	Left Temporal Pole	Left Transverse Temporal	Left Insula	Right Bankssts
Exposure score	Pearson Correlation	−0.227	−0.114	−0.142	−0.184	−0.157
	Sig. (2-tailed)	0.220	0.541	0.446	0.321	0.399
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.036	−0.149	−0.255	−0.334	0.109
	Sig. (2-tailed)	0.866	0.486	0.229	0.110	0.612
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.051	−0.217	0.292	−0.033	0.085
	Sig. (2-tailed)	0.826	0.345	0.199	0.886	0.713
	n	21	21	21	21	21
K10	Pearson Correlation	−0.284	−0.355	−0.185	−0.090	−0.221
	Sig. (2-tailed)	0.122	0.050	0.320	0.629	0.233
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.153	−0.201	−0.083	0.129	−0.258
	Sig. (2-tailed)	0.411	0.278	0.655	0.490	0.161
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.022	−0.083	0.143	−0.172	−0.270
	Sig. (2-tailed)	0.913	0.681	0.478	0.391	0.174
	n	27	27	27	27	27
	Sig. (2-tailed)	0.123	0.272	0.063	0.109	0.755
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.099	0.007	−0.125	0.135	0.064
	Sig. (2-tailed)	0.591	0.969	0.497	0.460	0.727
	n	32	32	32	32	32

		Right Caudal Anterior Cingulate	Right Caudal Middle Frontal	Right Cuneus	Right Entorhinal	Right Fusiform
Exposure score	Pearson Correlation	−0.233	−0.167	−0.122	−0.050	0.050
	Sig. (2-tailed)	0.207	0.368	0.512	0.791	0.790
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.104	−0.025	−0.172	−0.220	−0.104
	Sig. (2-tailed)	0.628	0.907	0.421	0.302	0.628
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.021	−0.185	−0.234	0.008	−0.033
	Sig. (2-tailed)	0.929	0.422	0.307	0.973	0.887
	n	21	21	21	21	21
K10	Pearson Correlation	0.021	0.000	0.107	−0.260	−.364
	Sig. (2-tailed)	0.912	0.998	0.568	0.157	0.044
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.206	0.047	0.186	−0.130	−0.229
	Sig. (2-tailed)	0.266	0.800	0.316	0.485	0.215
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.155	0.029	−0.195	−0.103	−0.012
	Sig. (2-tailed)	0.439	0.885	0.330	0.610	0.954
	n	27	27	27	27	27
	Sig. (2-tailed)	0.513	0.651	0.370	0.478	0.519
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.045	0.037	−0.133	−0.088	−0.175
	Sig. (2-tailed)	0.809	0.841	0.468	0.634	0.338
	n	32	32	32	32	32

		Right Inferior Parietal	Right Inferior Temporal	Right Isthmus Cingulate	Right Lateral Occipital	Right Lateral Orbitofrontal
Exposure score	Pearson Correlation	–0.121	–0.027	–0.155	–0.311	–0.035
	Sig. (2-tailed)	0.517	0.886	0.405	0.089	0.853
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	–.452	–0.155	–0.184	–.464	–0.323
	Sig. (2-tailed)	0.027	0.468	0.390	0.022	0.123
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	–0.068	0.298	–0.050	0.218	0.159
	Sig. (2-tailed)	0.770	0.189	0.830	0.343	0.491
	n	21	21	21	21	21
K10	Pearson Correlation	0.006	–0.037	–0.110	0.059	0.288
	Sig. (2-tailed)	0.974	0.843	0.555	0.753	0.117
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.134	–0.026	–0.063	0.080	0.284
	Sig. (2-tailed)	0.471	0.888	0.736	0.669	0.122
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	–0.284	–0.143	0.169	–0.196	–0.229
	Sig. (2-tailed)	0.150	0.477	0.399	0.327	0.251
	n	27	27	27	27	27
	Sig. (2-tailed)	0.006	0.703	0.616	0.224	0.074
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.138	0.010	–0.122	–0.146	–0.112
	Sig. (2-tailed)	0.451	0.956	0.505	0.425	0.542
	n	32	32	32	32	32

		Right Lingual	Right Medial Orbitofrontal	Right Middle Temporal	Right Parahippo-campal	Right Paracentral
Exposure score	Pearson Correlation	−0.235	−0.105	−0.110	0.031	−.429
	Sig. (2-tailed)	0.203	0.574	0.557	0.869	0.016
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.199	−0.141	−0.068	−0.210	−0.268
	Sig. (2-tailed)	0.350	0.512	0.752	0.324	0.205
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.046	0.234	0.269	0.059	−0.182
	Sig. (2-tailed)	0.843	0.307	0.239	0.800	0.430
	n	21	21	21	21	21
K10	Pearson Correlation	0.065	−0.130	−0.319	−0.184	0.042
	Sig. (2-tailed)	0.727	0.484	0.080	0.321	0.824
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.113	−0.190	−0.268	−0.197	0.156
	Sig. (2-tailed)	0.547	0.307	0.145	0.289	0.403
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.188	−0.131	−0.099	−0.043	−0.201
	Sig. (2-tailed)	0.348	0.514	0.624	0.830	0.315
	n	27	27	27	27	27
	Sig. (2-tailed)	0.013	0.421	0.877	0.627	0.043
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.084	−0.191	0.254	0.151	0.102
	Sig. (2-tailed)	0.646	0.294	0.161	0.410	0.579
	n	32	32	32	32	32

		Right Pars Opercularis	Right Pars Orbitalis	Right Pars Triangularis	Right Pericalcarine	Right Postcentral
Exposure score	Pearson Correlation	−0.135	0.193	0.146	0.045	−0.276
	Sig. (2-tailed)	0.470	0.298	0.434	0.810	0.133
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.020	0.053	0.033	−0.329	−0.281
	Sig. (2-tailed)	0.925	0.807	0.880	0.116	0.183
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.075	.496	0.116	−0.336	0.032
	Sig. (2-tailed)	0.747	0.022	0.618	0.137	0.889
	n	21	21	21	21	21
K10	Pearson Correlation	−0.202	0.009	−0.173	−0.060	−0.044
	Sig. (2-tailed)	0.275	0.962	0.351	0.747	0.813
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.128	0.057	−0.224	−0.126	0.004
	Sig. (2-tailed)	0.492	0.763	0.227	0.498	0.981
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.236	−.504	−0.169	0.003	−0.239
	Sig. (2-tailed)	0.235	0.007	0.398	0.990	0.230
	n	27	27	27	27	27
	Sig. (2-tailed)	0.416	0.973	0.596	0.398	0.192
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.076	0.080	0.201	−.355	−0.095
	Sig. (2-tailed)	0.678	0.663	0.270	0.046	0.607
	n	32	32	32	32	32

		Right Posterior Cingulate	Right Precentral	Right Precuneus	Right Rostral Anterior Cingulate	Right Rostral Middle Frontal
Exposure score	Pearson Correlation	−0.147	−0.109	−0.246	0.032	−0.205
	Sig. (2-tailed)	0.431	0.560	0.182	0.864	0.269
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.116	−0.029	−0.287	0.054	−0.256
	Sig. (2-tailed)	0.590	0.893	0.174	0.804	0.228
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.095	−0.100	−0.261	0.097	0.024
	Sig. (2-tailed)	0.683	0.665	0.253	0.677	0.918
	n	21	21	21	21	21
K10	Pearson Correlation	−0.007	−0.069	0.153	0.227	−0.231
	Sig. (2-tailed)	0.971	0.713	0.412	0.220	0.211
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.070	−0.001	.360	0.042	−0.218
	Sig. (2-tailed)	0.709	0.995	0.046	0.822	0.239
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.204	−0.166	−0.235	−0.232	−0.102
	Sig. (2-tailed)	0.307	0.407	0.238	0.245	0.612
	n	27	27	27	27	27
	Sig. (2-tailed)	0.443	0.809	0.237	0.032	0.560
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.145	−0.091	0.230	−0.083	0.120
	Sig. (2-tailed)	0.429	0.619	0.205	0.650	0.514
	n	32	32	32	32	32

		Right Superior Frontal	Right Superior Parietal	Right Superior Temporal	Right Supra-marginal	Right Frontal Pole
Exposure score	Pearson Correlation	−0.336	−0.355	−0.191	−0.226	0.076
	Sig. (2-tailed)	0.064	0.050	0.303	0.221	0.685
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.040	−0.222	−0.195	−0.303	−0.174
	Sig. (2-tailed)	0.851	0.296	0.361	0.151	0.416
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.000	−0.026	−0.059	0.322	0.317
	Sig. (2-tailed)	1.000	0.912	0.799	0.154	0.161
	n	21	21	21	21	21
K10	Pearson Correlation	−0.216	−0.187	0.062	−0.036	−0.091
	Sig. (2-tailed)	0.244	0.314	0.740	0.847	0.627
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.125	0.085	0.282	0.138	−0.173
	Sig. (2-tailed)	0.502	0.649	0.125	0.461	0.352
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.157	−0.274	−0.159	−.509	−0.117
	Sig. (2-tailed)	0.435	0.166	0.429	0.007	0.561
	n	27	27	27	27	27
	Sig. (2-tailed)	0.504	0.222	0.104	0.181	0.169
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.176	0.179	0.291	−0.060	−0.017
	Sig. (2-tailed)	0.336	0.328	0.106	0.744	0.928
	n	32	32	32	32	32

		Right Temporal Pole	Right Transverse Temporal	Right insula
Exposure score	Pearson Correlation	0.217	−0.041	−0.032
	Sig. (2-tailed)	0.241	0.826	0.862
	n	31	31	31
Exposure to explosions	Pearson Correlation	0.095	−0.288	0.107
	Sig. (2-tailed)	0.658	0.172	0.618
	n	24	24	24
Number of TBIs	Pearson Correlation	0.170	−0.159	−0.096
	Sig. (2-tailed)	0.461	0.491	0.680
	n	21	21	21
K10	Pearson Correlation	−0.161	0.316	−0.167
	Sig. (2-tailed)	0.387	0.083	0.370
	n	31	31	31
PCL-C	Pearson Correlation	−0.049	.443	−0.010
	Sig. (2-tailed)	0.793	0.012	0.957
	n	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.191	0.080	−0.251
	Sig. (2-tailed)	0.340	0.692	0.206
	n	27	27	27
	Sig. (2-tailed)	0.699	0.071	0.603
	n	34	34	34
Working memory	Pearson Correlation	0.212	0.085	0.019
	Sig. (2-tailed)	0.243	0.642	0.917
	n	32	32	32

C.4　Associations between fractional anistropy (FA) and psychological, exposure and cognitive indices

		Fornix (column and body of fornix) (FX)	Right Cortico-spinal Tract (7) (CST_R)	Left Cortico-spinal Tract (8) (CST_L)	Right Medial Lemniscus (9) (ML_R)	Left Medial Lemniscus (10) (ML_L)
Exposure score	Pearson Correlation	0.097	.c	0.172	.c	−0.235
	Sig. (2-tailed)	0.603		0.356		0.203
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.154	.c	0.069	.c	0.167
	Sig. (2-tailed)	0.474		0.750		0.437
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.120	.c	0.297	.c	0.117
	Sig. (2-tailed)	0.605		0.191		0.612
	n	21	21	21	21	21
K10	Pearson Correlation	−0.015	.c	−0.259	.c	−0.098
	Sig. (2-tailed)	0.935		0.159		0.602
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.038	.c	−0.177	.c	−0.135
	Sig. (2-tailed)	0.840		0.341		0.468
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.077	.c	−0.292	.c	−0.106
	Sig. (2-tailed)	0.702		0.140		0.598
	n	27	27	27	27	27
	Sig. (2-tailed)	0.431		0.684		0.300
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.317	.c	0.016	.c	0.038
	Sig. (2-tailed)	0.077		0.930		0.836
	n	32	32	32	32	32

		Right Inferior Cerebellar Peduncle (11) (ICP_R)	Left Inferior Cerebellar Peduncle (12) (ICP_L)	Right Superior Cerebellar Peduncle (13) (SCP_R)	Left Superior Cerebellar Peduncle (14)	Right Cerebral Peduncle (15) (CP_R)
Exposure score	Pearson Correlation	0.072	−0.023	0.011	0.176	0.226
	Sig. (2-tailed)	0.699	0.902	0.954	0.342	0.222
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.065	−0.057	0.031	0.127	−0.053
	Sig. (2-tailed)	0.763	0.790	0.885	0.553	0.807
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.085	−0.077	0.034	−0.014	0.273
	Sig. (2-tailed)	0.713	0.739	0.885	0.953	0.230
	n	21	21	21	21	21
K10	Pearson Correlation	0.163	0.149	0.013	−0.069	−0.163
	Sig. (2-tailed)	0.381	0.425	0.943	0.714	0.381
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.108	0.151	−0.053	−0.070	−0.055
	Sig. (2-tailed)	0.564	0.416	0.775	0.708	0.768
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.055	0.011	0.008	−0.244	−0.147
	Sig. (2-tailed)	0.784	0.955	0.969	0.220	0.465
	n	27	27	27	27	27
	Sig. (2-tailed)	0.350	0.651	0.289	0.270	0.582
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.195	−0.248	−.446	−0.280	0.037
	Sig. (2-tailed)	0.285	0.172	0.011	0.120	0.842
	n	32	32	32	32	32

		Left Cerebral Peduncle (16) (CP_L)	Right Anterior Limb of Internal Capsule (17) (ALIC_R)	Left Anterior Limb of Internal Capsule (18) (ALIC_L)	Right Posterior Limb of Internal Capsule (19) (PLIC_R)	Left Posterior Limb of Internal Capsule (20) (PLIC_L)
Exposure score	Pearson Correlation	0.227	.515	.447	0.196	0.312
	Sig. (2-tailed)	0.220	0.003	0.012	0.292	0.088
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.019	0.115	0.003	0.063	0.062
	Sig. (2-tailed)	0.931	0.593	0.988	0.770	0.772
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.255	0.093	0.223	0.038	0.023
	Sig. (2-tailed)	0.265	0.687	0.331	0.871	0.922
	n	21	21	21	21	21
K10	Pearson Correlation	−0.130	−0.197	−.364	0.060	−.355
	Sig. (2-tailed)	0.487	0.288	0.044	0.750	0.050
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.044	−0.172	−.366	0.154	−0.256
	Sig. (2-tailed)	0.813	0.354	0.043	0.407	0.164
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.143	−0.067	0.045	−0.245	−0.164
	Sig. (2-tailed)	0.478	0.741	0.822	0.218	0.414
	n	27	27	27	27	27
	Sig. (2-tailed)	0.302	0.191	0.181	0.661	0.246
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.084	−0.025	0.163	−0.098	0.076
	Sig. (2-tailed)	0.647	0.893	0.374	0.594	0.679
	n	32	32	32	32	32

		Right Retro-lenticular Part of Internal Capsule (21) (RLIC_R)	Left Retro-lenticular Part of Internal Capsule (22) (RLIC_L)	Right Anterior Corona Radiata (23) (ACRight R)	Left Anterior Corona Radiata (24) (ACRight L)	Right Superior Corona Radiata (25) (SCRight R)
Exposure score	Pearson Correlation	0.120	0.162	0.243	0.318	0.035
	Sig. (2-tailed)	0.519	0.383	0.188	0.082	0.851
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.008	0.114	0.065	0.103	0.013
	Sig. (2-tailed)	0.970	0.597	0.761	0.631	0.951
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.031	0.060	0.114	0.091	0.223
	Sig. (2-tailed)	0.894	0.795	0.622	0.693	0.331
	n	21	21	21	21	21
K10	Pearson Correlation	0.207	0.015	0.301	−0.065	0.101
	Sig. (2-tailed)	0.263	0.937	0.100	0.728	0.589
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.332	0.089	0.242	−0.158	0.187
	Sig. (2-tailed)	0.068	0.632	0.189	0.396	0.313
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.306	−0.199	−0.276	−0.171	−0.219
	Sig. (2-tailed)	0.121	0.320	0.163	0.394	0.272
	n	27	27	27	27	27
	Sig. (2-tailed)	0.779	0.255	0.777	0.146	0.964
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.126	−0.116	−0.026	0.232	−0.180
	Sig. (2-tailed)	0.490	0.529	0.888	0.201	0.325
	n	32	32	32	32	32

		Left Superior Corona Radiata (26) (SCRight L)	Right Posterior Corona Radiata (27) (PCRight R)	Left Posterior Corona Radiata (28) (PCRight L)	Right Posterior Thalamic Radiation (include optic radiation) (29) (PTRight R)	Left Posterior Thalamic Radiation (include optic radiation) (30) (PTRight L)
Exposure score	Pearson Correlation	0.040	0.075	−0.002	0.058	0.035
	Sig. (2-tailed)	0.830	0.688	0.991	0.756	0.853
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.056	0.242	0.354	0.226	0.185
	Sig. (2-tailed)	0.794	0.255	0.090	0.288	0.386
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.061	0.406	.441	0.287	0.304
	Sig. (2-tailed)	0.794	0.068	0.045	0.208	0.180
	n	21	21	21	21	21
K10	Pearson Correlation	−0.093	0.095	−0.089	0.009	0.076
	Sig. (2-tailed)	0.619	0.610	0.635	0.961	0.685
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.038	0.178	0.105	0.191	0.056
	Sig. (2-tailed)	0.839	0.337	0.574	0.304	0.765
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.187	−.432	−0.298	−0.368	−.394
	Sig. (2-tailed)	0.351	0.024	0.131	0.059	0.042
	n	27	27	27	27	27
	Sig. (2-tailed)	0.687	0.561	0.927	0.505	0.713
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.020	−0.067	0.075	0.102	−0.149
	Sig. (2-tailed)	0.914	0.717	0.685	0.578	0.417
	n	32	32	32	32	32

		Right Sagittal Stratum (include inferior longitudinal fasciculus and inferior fronto-occipital fasciculus) (31) (SS_R)	Left Sagittal Stratum (include inferior longitudinal fasciculus and inferior fronto-occipital fasciculus) (32) (SS_L)	Right External Capsule (33) (EC_R)	Left External Capsule (34) (EC_L)	Right Cingulum (cingulate gyrus) (35) (CCG_R)
Exposure score	Pearson Correlation	0.075	0.229	0.011	0.051	0.153
	Sig. (2-tailed)	0.687	0.216	0.952	0.786	0.410
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.078	0.088	−0.049	0.130	0.034
	Sig. (2-tailed)	0.718	0.684	0.820	0.545	0.873
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.298	0.114	0.345	0.202	0.201
	Sig. (2-tailed)	0.190	0.623	0.126	0.379	0.383
	n	21	21	21	21	21
K10	Pearson Correlation	0.211	0.260	0.146	−0.224	0.187
	Sig. (2-tailed)	0.254	0.158	0.435	0.226	0.313
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.314	0.344	0.248	−0.239	0.307
	Sig. (2-tailed)	0.085	0.058	0.179	0.196	0.093
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.307	−0.362	−.472	−0.341	−0.309
	Sig. (2-tailed)	0.119	0.064	0.013	0.082	0.116
	n	27	27	27	27	27
	Sig. (2-tailed)	0.640	0.295	0.581	0.451	0.959
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.116	−0.077	−0.123	0.081	−0.111
	Sig. (2-tailed)	0.527	0.676	0.502	0.658	0.544
	n	32	32	32	32	32

		Left Cingulum (cingulate gyrus) (36) (CCG_L)	Right Cingulum (hippo-campus) (37) (CGH_R)	Left Cingulum (hippo-campus) (38) (CGH-L)	Right Fornix (cres) / Stria Terminalis (cannot be resolved with current resolution) (39) (FX/ST_R)	Left Fornix (cres) / Stria Terminalis (cannot be resolved with current resolution) (40) (FX/ST_L)
Exposure score	Pearson Correlation	0.178	–0.188	–0.037	0.026	0.286
	Sig. (2-tailed)	0.337	0.311	0.844	0.888	0.119
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.154	–0.223	0.018	–0.007	0.186
	Sig. (2-tailed)	0.472	0.294	0.935	0.973	0.384
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.080	–0.335	–0.310	–0.051	0.118
	Sig. (2-tailed)	0.730	0.138	0.171	0.827	0.609
	n	21	21	21	21	21
K10	Pearson Correlation	–0.108	0.010	–0.114	0.143	0.095
	Sig. (2-tailed)	0.562	0.958	0.540	0.444	0.610
	n	31	31	31	31	31
PCL-C	Pearson Correlation	–0.003	0.120	–0.062	0.240	0.194
	Sig. (2-tailed)	0.985	0.519	0.739	0.193	0.297
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	–0.136	0.018	–0.043	–.395	–0.103
	Sig. (2-tailed)	0.500	0.931	0.833	0.041	0.608
	n	27	27	27	27	27
	Sig. (2-tailed)	0.387	0.586	0.930	0.224	0.249
	n	34	34	34	34	34
Working memory	Pearson Correlation	–0.028	0.030	–0.010	–0.114	–0.119
	Sig. (2-tailed)	0.878	0.872	0.957	0.534	0.518
	n	32	32	32	32	32

		Right Superior Longitudinal Fasciculus (41)	Left Superior Longitudinal Fasciculus (42)	Right Superior Fronto-occipital Fasciculus (could be a part of anterior internal capsule) (43)	Left Superior Fronto-occipital Fasciculus (could be a part of anterior internal capsule) (44)	Right Uncinate Fasciculus (45)	Left Uncinate Fasciculus (46)
Exposure score	Pearson Correlation	-0.298	0.071	0.242	.385	-0.023	0.238
	Sig. (2-tailed)	0.104	0.705	0.189	0.032	0.903	0.198
	n	31	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.098	0.280	-0.111	-0.054	-0.024	0.010
	Sig. (2-tailed)	0.648	0.184	0.607	0.802	0.911	0.963
	n	24	24	24	24	24	24
Number of TBIs	Pearson Correlation	-.481	0.284	0.007	0.250	0.134	0.100
	Sig. (2-tailed)	0.027	0.212	0.976	0.274	0.561	0.667
	n	21	21	21	21	21	21
K10	Pearson Correlation	-0.112	0.046	0.005	-0.302	0.011	-0.203
	Sig. (2-tailed)	0.550	0.807	0.980	0.099	0.954	0.275
	n	31	31	31	31	31	31
PCL-C	Pearson Correlation	-0.038	0.039	-0.007	-.368	-0.042	-0.215
	Sig. (2-tailed)	0.839	0.837	0.970	0.042	0.821	0.245
	n	31	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	-0.228	-.447	-0.047	0.233	-0.241	-0.141
	Sig. (2-tailed)	0.253	0.019	0.815	0.242	0.226	0.483
	n	27	27	27	27	27	27
	Sig. (2-tailed)	0.672	0.599	0.488	0.308	0.875	0.085
	n	34	34	34	34	34	34
Working memory	Pearson Correlation	-0.283	-0.048	-0.029	0.166	0.049	0.196
	Sig. (2-tailed)	0.116	0.793	0.876	0.364	0.791	0.283
	n	32	32	32	32	32	32

C.5 Associations between mean diffusivity (MD) and psychological, exposure and cognitive indices

		Middle Cerebellar Peduncle (1)	Pontine Crossing Tract (2)	Genu of Corpus Callosum (3)	Body of Corpus Callosum (4)	Splenium of Corpus Callosum (5)
Exposure score	Pearson Correlation	0.251	0.189	0.132	0.339	0.335
	Sig. (2-tailed)	0.174	0.308	0.481	0.062	0.065
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.110	0.362	–0.101	0.007	0.121
	Sig. (2-tailed)	0.610	0.082	0.640	0.974	0.573
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	.489	0.320	–0.100	0.337	.450
	Sig. (2-tailed)	0.024	0.157	0.666	0.135	0.040
	n	21	21	21	21	21
K10	Pearson Correlation	–0.261	–0.067	–0.050	0.080	0.102
	Sig. (2-tailed)	0.156	0.719	0.788	0.667	0.586
	n	31	31	31	31	31
PCL-C	Pearson Correlation	–0.271	–0.024	–0.001	–0.058	–0.045
	Sig. (2-tailed)	0.141	0.899	0.996	0.759	0.811
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.292	0.128	–0.103	0.166	0.150
	Sig. (2-tailed)	0.140	0.525	0.610	0.409	0.456
	n	27	27	27	27	27
	Sig. (2-tailed)	0.033	0.074	0.376	0.398	0.088
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.305	0.266	0.144	0.263	0.250
	Sig. (2-tailed)	0.090	0.141	0.432	0.147	0.167
	n	32	32	32	32	32

		Fornix (column and body of fornix) (6)	Right Cortico-spinal Tract (7)	Left Cortico-spinal Tract (8)	Right Medial Lemniscus (9)	Left Medial Lemniscus (10)
Exposure score	Pearson Correlation	0.071	.[a]	0.186	.[a]	0.154
	Sig. (2-tailed)	0.703		0.317		0.409
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.036	.[a]	0.155	.[a]	0.213
	Sig. (2-tailed)	0.866		0.470		0.318
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.097	.[a]	0.262	.[a]	0.364
	Sig. (2-tailed)	0.677		0.252		0.104
	n	21	21	21	21	21
K10	Pearson Correlation	0.227	.[a]	−0.113	.[a]	−0.056
	Sig. (2-tailed)	0.219		0.545		0.764
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.033	.[a]	−0.185	.[a]	−0.078
	Sig. (2-tailed)	0.860		0.318		0.675
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	−0.098	.[a]	0.240	.[a]	0.171
	Sig. (2-tailed)	0.628		0.227		0.395
	n	27	27	27	27	27
	Sig. (2-tailed)	0.721		0.006		0.033
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.055	.[a]	0.106	.[a]	0.274
	Sig. (2-tailed)	0.765		0.565		0.129
	n	32	32	32	32	32

		Right Inferior Cerebellar Peduncle (11)	Left Inferior Cerebellar Peduncle (12)	Right Superior Cerebellar Peduncle (13)	Left Superior Cerebellar Peduncle (14)	Right Cerebral Peduncle (15)
Exposure score	Pearson Correlation	0.186	0.113	0.173	0.120	0.112
	Sig. (2-tailed)	0.317	0.546	0.353	0.519	0.548
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.150	0.171	0.224	0.181	0.154
	Sig. (2-tailed)	0.483	0.425	0.293	0.398	0.472
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.450	0.302	0.591	0.411	0.170
	Sig. (2-tailed)	0.041	0.183	0.005	0.064	0.462
	n	21	21	21	21	21
K10	Pearson Correlation	−0.167	−0.171	−0.059	0.023	0.003
	Sig. (2-tailed)	0.369	0.356	0.751	0.901	0.987
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.263	−0.118	−0.157	−0.048	0.002
	Sig. (2-tailed)	0.152	0.528	0.400	0.799	0.993
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.187	0.280	0.345	0.153	0.128
	Sig. (2-tailed)	0.351	0.157	0.078	0.445	0.525
	n	27	27	27	27	27
	Sig. (2-tailed)	0.090	0.040	0.107	0.059	0.022
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.340	0.384	0.212	0.255	0.195
	Sig. (2-tailed)	0.057	0.030	0.243	0.158	0.285
	n	32	32	32	32	32

		Left Cerebral Peduncle (16)	Right Anterior Limb of Internal Capsule (17)	Left Anterior Limb of Internal Capsule (18)	Right Posterior Limb of Internal Capsule (19)	Left Posterior Limb of Internal Capsule (20)
Exposure score	Pearson Correlation	0.135	0.243	0.072	0.319	0.241
	Sig. (2-tailed)	0.468	0.187	0.700	0.080	0.192
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.091	0.104	0.014	0.164	0.116
	Sig. (2-tailed)	0.672	0.629	0.948	0.442	0.588
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.033	−0.417	−.557	−0.024	−0.420
	Sig. (2-tailed)	0.886	0.060	0.009	0.917	0.058
	n	21	21	21	21	21
K10	Pearson Correlation	0.030	−0.206	−0.090	−0.101	−0.117
	Sig. (2-tailed)	0.873	0.267	0.629	0.588	0.531
	n	31	31	31	31	31
PCL-C	Pearson Correlation	0.030	−0.229	0.047	−0.198	−0.049
	Sig. (2-tailed)	0.873	0.216	0.802	0.286	0.792
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.057	0.107	−0.025	0.136	0.046
	Sig. (2-tailed)	0.776	0.594	0.902	0.499	0.818
	n	27	27	27	27	27
	Sig. (2-tailed)	0.028	0.629	0.760	0.042	0.011
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.184	−0.161	−0.151	0.204	0.176
	Sig. (2-tailed)	0.313	0.378	0.408	0.264	0.336
	n	32	32	32	32	32

		Right Retro-lenticular Part of Internal Capsule (21)	Left Retro-lenticular Part of Internal Capsule (22)	Right Anterior Corona Radiata (23)	Left Anterior Corona Radiata (24)	Right Superior Corona Radiata (25)
Exposure score	Pearson Correlation	0.278	0.265	0.260	0.168	.389
	Sig. (2-tailed)	0.130	0.149	0.159	0.367	0.031
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.149	−0.084	−0.204	−0.219	0.022
	Sig. (2-tailed)	0.486	0.697	0.338	0.304	0.918
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.194	0.113	−0.004	−0.192	0.339
	Sig. (2-tailed)	0.400	0.627	0.987	0.405	0.133
	n	21	21	21	21	21
K10	Pearson Correlation	−0.159	−0.052	−0.185	−0.106	0.001
	Sig. (2-tailed)	0.394	0.782	0.319	0.572	0.995
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.227	−0.097	−0.141	−0.075	−0.165
	Sig. (2-tailed)	0.220	0.602	0.450	0.689	0.376
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.225	0.019	0.121	0.041	0.201
	Sig. (2-tailed)	0.260	0.923	0.546	0.838	0.315
	n	27	27	27	27	27
	Sig. (2-tailed)	0.017	0.283	0.361	0.470	0.920
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.294	0.043	0.141	0.041	0.069
	Sig. (2-tailed)	0.102	0.813	0.440	0.822	0.706
	n	32	32	32	32	32

		Left Superior Corona Radiata (26)	Right Posterior Corona Radiata (27)	Left Posterior Corona Radiata (28)	Right Posterior Thalamic Radiation (include optic radiation) (29)	Left Posterior Thalamic Radiation (include optic radiation) (30)
Exposure score	Pearson Correlation	0.284	.360	0.316	0.277	0.265
	Sig. (2-tailed)	0.122	0.046	0.083	0.131	0.149
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.005	−0.096	−0.118	0.063	0.078
	Sig. (2-tailed)	0.983	0.656	0.583	0.770	0.718
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	−0.010	0.399	.472	0.342	0.155
	Sig. (2-tailed)	0.964	0.073	0.031	0.129	0.503
	n	21	21	21	21	21
K10	Pearson Correlation	−0.030	0.060	0.115	−0.009	−0.053
	Sig. (2-tailed)	0.874	0.750	0.537	0.960	0.778
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.149	−0.132	−0.056	−0.015	−0.192
	Sig. (2-tailed)	0.424	0.480	0.764	0.938	0.300
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.146	0.248	0.199	0.212	0.309
	Sig. (2-tailed)	0.468	0.213	0.321	0.287	0.116
	n	27	27	27	27	27
	Sig. (2-tailed)	0.958	0.826	0.509	0.125	0.477
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.127	0.051	0.077	0.209	0.141
	Sig. (2-tailed)	0.489	0.781	0.675	0.252	0.442
	n	32	32	32	32	32

		Right Sagittal Stratum (include inferior longitudinal fasciculus and inferior fronto-occipital fasciculus) (31)	Left Sagittal Stratum (include inferior longitudinal fasciculus and inferior fronto-occipital fasciculus) (32)	Right External Capsule (33)	Left External Capsule (34)	Right Cingulum (cingulate gyrus) (35)
Exposure score	Pearson Correlation	0.187	0.243	0.383	0.144	0.382
	Sig. (2-tailed)	0.314	0.189	0.033	0.441	0.034
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.153	0.023	−0.008	0.047	0.090
	Sig. (2-tailed)	0.476	0.915	0.972	0.826	0.676
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.392	0.226	0.204	−0.321	0.295
	Sig. (2-tailed)	0.079	0.326	0.376	0.156	0.193
	n	21	21	21	21	21
K10	Pearson Correlation	−.362	−0.117	−0.159	−0.039	0.125
	Sig. (2-tailed)	0.046	0.532	0.394	0.836	0.504
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−.460	−0.176	−0.207	0.061	−0.057
	Sig. (2-tailed)	0.009	0.344	0.265	0.745	0.762
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.171	0.058	0.036	−0.084	0.194
	Sig. (2-tailed)	0.393	0.773	0.857	0.676	0.332
	n	27	27	27	27	27
	Sig. (2-tailed)	0.019	0.240	0.984	0.972	0.842
	n	34	34	34	34	34
Working memory	Pearson Correlation	0.287	0.162	0.066	−0.090	0.088
	Sig. (2-tailed)	0.112	0.376	0.721	0.625	0.632
	n	32	32	32	32	32

		Left Cingulum (cingulate gyrus) (36)	Right Cingulum (hippo-campus) (37)	Left Cingulum (hippo-campus) (38)	Right Fornix (cres) / Stria Terminalis (cannot be resolved with current resolution) (39)	Left Fornix (cres) / Stria Terminalis (cannot be resolved with current resolution) (40)
Exposure score	Pearson Correlation	0.342	0.063	0.179	0.175	0.469
	Sig. (2-tailed)	0.060	0.738	0.336	0.345	0.008
	n	31	31	31	31	31
Exposure to explosions	Pearson Correlation	0.034	0.074	0.050	0.147	0.124
	Sig. (2-tailed)	0.874	0.732	0.816	0.494	0.564
	n	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.273	0.265	0.253	0.129	0.243
	Sig. (2-tailed)	0.231	0.245	0.268	0.576	0.288
	n	21	21	21	21	21
K10	Pearson Correlation	0.121	−0.107	−0.133	0.007	−0.034
	Sig. (2-tailed)	0.515	0.566	0.475	0.971	0.856
	n	31	31	31	31	31
PCL-C	Pearson Correlation	−0.141	−0.093	−0.149	−0.044	−0.068
	Sig. (2-tailed)	0.450	0.618	0.424	0.814	0.715
	n	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.158	0.103	0.121	0.217	0.059
	Sig. (2-tailed)	0.430	0.611	0.547	0.277	0.771
	n	27	27	27	27	27
	Sig. (2-tailed)	0.716	0.022	0.009	0.053	0.202
	n	34	34	34	34	34
Working memory	Pearson Correlation	−0.002	0.175	0.141	0.213	0.107
	Sig. (2-tailed)	0.993	0.338	0.443	0.242	0.558
	n	32	32	32	32	32

		Right Superior Longitudinal Fasciculus (41)	Left Superior Longitudinal Fasciculus (42)	Right Superior Fronto-occipital Fasciculus (could be a part of anterior internal capsule) (43)	Left Superior Fronto-occipital Fasciculus (could be a part of anterior internal capsule) (44)	Right Uncinate Fasciculus (45)	Left Uncinate Fasciculus (46)
Exposure score	Pearson Correlation	0.364	0.253	0.287	0.004	0.029	0.201
	Sig. (2-tailed)	0.044	0.170	0.118	0.984	0.879	0.279
	n	31	31	31	31	31	31
Exposure to explosions	Pearson Correlation	−0.060	−0.109	−0.039	−0.231	−0.221	0.015
	Sig. (2-tailed)	0.782	0.611	0.856	0.277	0.299	0.946
	n	24	24	24	24	24	24
Number of TBIs	Pearson Correlation	0.362	0.155	0.259	0.064	0.220	−0.266
	Sig. (2-tailed)	0.106	0.502	0.258	0.783	0.339	0.243
	n	21	21	21	21	21	21
K10	Pearson Correlation	0.004	−0.045	0.016	−0.007	−0.125	0.215
	Sig. (2-tailed)	0.985	0.812	0.930	0.969	0.504	0.246
	n	31	31	31	31	31	31
PCL-C	Pearson Correlation	−0.161	−0.148	−0.003	−0.023	−0.129	0.320
	Sig. (2-tailed)	0.388	0.428	0.988	0.903	0.489	0.079
	n	31	31	31	31	31	31
Post-concussive symptoms	Pearson Correlation	0.209	0.120	0.135	−0.124	0.052	−0.151
	Sig. (2-tailed)	0.296	0.552	0.502	0.538	0.796	0.453
	n	27	27	27	27	27	27
	Sig. (2-tailed)	0.735	0.806	0.896	0.518	0.535	0.089
	n	34	34	34	34	34	34
Working memory	Pearson Correlation	0.073	0.105	0.205	0.115	−0.122	−0.126
	Sig. (2-tailed)	0.691	0.568	0.259	0.530	0.507	0.493
	n	32	32	32	32	32	32

Annex D Supplementary traumatic brain injury material

D.1 Defining mild traumatic brain injury

As noted in a 2011 Australian report, *Loss of Consciousness and IEDs: the issues and challenges in diagnosing mTBI*, the two most widely used definitions for mTBI reported in scientific research studies are from the World Health Organization and the US Centers for Disease Control and Prevention (McFarlane et al., 2011a).

The WHO Collaborating Centre Task Force (Carroll et al., 2004a, 2004b) defined mTBI in 2004 thus:

> An acute brain injury resulting from mechanical energy to the head from external physical forces. Operational criteria for clinical identification include: (i) 1 or more of the following: confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and/or other transient neurological abnormalities such as focal signs, seizure, and intracranial lesion not requiring surgery; (ii) Glasgow Coma Scale score of 13–15 after 30 minutes post-injury or later upon presentation for healthcare. These manifestations of MTBI must not be due to drugs, alcohol, medications, caused by other injuries or treatment for other injuries (e.g. systemic injuries, facial injuries or intubation), caused by other problems (e.g. psychological trauma, language barrier or coexisting medical conditions) or caused by penetrating craniocerebral injury.

This definition was derived from the 1993 definition developed by the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine. Although the WHO Task Force agreed with the American Congress of Rehabilitation Medicine definition, which specifies that the Glasgow Coma Scale score of 13–15 be assessed 30 minutes post-injury, the WHO Task Force recognised the practical limitation in that an individual with mTBI will rarely be assessed within a 30-minute time frame and so allowed some provision for retrospective diagnosis on presentation in the healthcare setting.

The characteristics of loss or alteration of consciousness, post-traumatic amnesia and the Glasgow Coma Scale score have similarities with the conceptual definition of mTBI that was provided by the US Centers for Disease Control and Prevention's mTBI Working Group in 2003:

> A case of mTBI is an occurrence of injury to the head resulting from blunt trauma or acceleration or deceleration forces with one or more of the following conditions attributable to the head injury during the surveillance period:

- Any period of observed or self-reported transient confusion, disorientation, or impaired consciousness;

- Any period of observed or self-reported dysfunction of memory (amnesia) around the time of injury;

- Observed signs of other neurological or neuropsychological dysfunction, such as –

    – Seizures acutely following head injury;

    – Among infants and very young children: irritability, lethargy, or vomiting following head injury;

    – Symptoms among older children and adults such as headache, dizziness, irritability, fatigue, or poor concentration, when identified soon after injury, can be used to support the diagnosis of mild TBI, but cannot be used to make the diagnosis in the absence of loss of consciousness or altered consciousness. Further research may provide additional guidance in this area.

    – Any period of observed or self-reported loss of consciousness lasting 30 minutes or less.

- More severe brain injuries were excluded from the definition of MTBI and include one or more of the following conditions attributable to the injury:

- Loss of consciousness lasting longer than 30 minutes;

- Post-traumatic amnesia lasting longer than 24 hours;

- Penetrating craniocerebral injury. (National Center for Injury Prevention and Control, 2003)

In addition to this conceptual definition of mTBI based on clinical signs, symptoms and neuroimaging, the CDC's MTBI Working Group Definitions Subgroup developed an operational definition to be used in identifying cases of mTBI in administrative databases, medical records, and survey and interview results (National Center for Injury Prevention and Control, 2003). These two definitions have since been used as a basis for US military screening programs.

The 2011 Australian report highlighted some limitations with the definitions used (McFarlane et al., 2011a). Although the upper limits of mTBI criteria are clearly stated in the definitions – for example, in an injury event, loss or alteration of consciousness for 31 minutes or for 29 minutes would be classified as moderate TBI and mTBI respectively – there are no explicit guidelines for classification of injury (if any) identified by a period of 10 seconds of 'confusion or disorientation'. Additionally, it should be noted that a Glasgow Coma Scale score of 15 is the highest possible score, which actually reflects normal functioning (McFarlane et al., 2011a).

D.2   The non-specific nature of post-concussive symptoms

An accurate diagnosis of mTBI cannot be made on a symptomatic basis since PCS associated with mTBI as just described are highly non-specific in nature (Stein et al., 2016). The presence of these symptoms alone is not sufficient for a diagnosis of TBI (Assistant Secretary of Defense, 2015). These symptoms and those of psychiatric disorders such as PTSD and depression overlap greatly and thus can be misattributed to mTBI. Given the high rate of comorbidities among veterans and service personnel, particularly concurrent PTSD, it further confounds the difficulty in making an accurate diagnosis and in establishing a causal link (McFarlane et al., 2011a).

The relationship between mental health conditions and PCS has been identified in many other civilian and military studies. Hoge et al. (2008) found that, among US soldiers returning from deployment to Iraq who reported mTBI with loss of consciousness for less than 30 minutes, 44% met criteria for PTSD and 23% met criteria for depression. The association of mTBI with PCS was no longer significant after adjusting for PTSD and depression.

Garber et al. (2016) confirmed findings of the association between PCS and non-TBI injury. They found a history of mTBI had no significant independent association with PCS after controlling for confounding factors. In contrast, mental health problems had a strong association with reporting three or more PCS (adj PR = 7.77; 95% CI 6.60–9.15).

Caution is required when interpreting findings from studies investigating the aetiology of PCS since the symptoms can be influenced by many factors, as discussed further in the 2011 report (McFarlane et al., 2011a). Individuals experiencing depression, PTSD, chronic pain or other psychiatric concerns during or after deployment might misattribute their symptoms to mTBI. PTSD is a disorder with significant overlap with deployment-related mTBI, in both symptom profiles and aetiology, in that both can arise from the same combat experience. A thorough and comprehensive assessment to explore possible explanations for reporting of post-concussive symptoms is necessary, and psychiatric comorbidity must be considered when an individual presents with post-concussive symptoms.

For symptoms that persist beyond the standard recovery period it is less likely that causality can be confirmed (McFarlane et al., 2011a). The determinants of prolonged symptoms appeared to be related to other personal and social factors, rather than the mTBI itself (Carroll et al., 2004b). The differential impact of mTBI or PTSD diagnosis can influence reporting and interpretation of symptoms by symptomatic individuals. Personnel can be aware of consequences, which include potential grounds for military discharge, compensation eligibility and care priority depending on their diagnosis, which can also vary in overseas military and healthcare systems.

D.3   The association of mTBI with psychological health outcomes

The overlap between mTBI and PTSD in terms of symptom profile and aetiology has been explored in the literature, as discussed, and with conflicting results, as discussed in the 2011 report (McFarlane et al., 2011a). While Hoge et al. (2008) reported that PTSD and depression mediated the relationship between mTBI and PCS, Polusny et al. (2011) concluded from their longitudinal study of US veterans who had deployed to Iraq and Afghanistan that PTSD symptoms confounded this relationship.

Rona et al. (2012a) found that mTBI in UK personnel in 2007 to 2009 who had deployed to Afghanistan and/or Iraq was associated with current symptoms of PTSD assessed using the PCL, alcohol misuse assessed using the AUDIT, and multiple physical symptoms assessed as 18 or more symptoms reported on the symptom checklist compared with having another injury.

D.4   The association of mTBI with functional health outcomes

There has been limited research on functional outcomes in relation to mTBI. Follow-up of Canadian Armed Forces after deployment to Afghanistan found that 6.6% developed a career-limiting medical condition and mTBI was independently associated with career-limiting medical conditions. Musculoskeletal conditions (25.9%) and mental disorders (55.4%) were the primary diagnoses most commonly associated with career-limiting medical conditions in those with mTBI (Garber et al., 2016).

Acronyms

ABS	Australian Bureau of Statistics
ADF	Australian Defence Force
AIFS	Australian Institute of Family Studies
AIHW	Australian Institute of Health and Welfare
ANOVA	analysis of variance
AUDIT	Alcohol Use Disorders Identification Test
BMI	body mass index
BRS	Ohio State University Brief Resilience Scale
CDC	Centers for Disease Control and Prevention
CI	confidence interval
CIDI	Composite International Diagnostic Interview (WHO)
CRC	cooperative research centre
CTSS	Centre for Traumatic Stress Studies
DAR-5	Dimensions of Anger Reactions Scale
DMAC	Data Management & Analysis Centre
DSM-IV	*Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*
DVA	Department of Veterans' Affairs
ERP	event-related potential
ESO	ex-service organisation
ESR	erythrocyte sedimentation rate
GAD	generalised anxiety disorder
GAD-7	Generalised Anxiety Disorder 7-item Scale
HBA1C	glycated haemoglobin
HILDA	Household, Income and Labour Dynamics in Australia
HREC	Human Research Ethics Committee
HRF	Hunter Research Foundation
ICD-10	International Statistical Classification of Diseases and Related Health Problems – 10th Revision
IED	improvised explosive device
K10	Kessler Psychological Distress Scale

KCMHR	King's Centre for Military Health Research, Academic Department of Military Mental Health
MEAO	Middle East Area of Operations
MEC	Medical Employment Classification
MECRB	Medical Employment Classification Review Board
MHPWS	Mental Health Prevalence and Wellbeing Study
MilHOP	Military Health Outcomes Program
MRI	magnetic resonance imaging
mTBI	mild traumatic brain injury
NCO	Non-Commissioned Officer
NDI	National Death Index
NHMRC	National Health and Medical Research Council
NHS	National Health Survey
OCD	obsessive–compulsive disorder
OFFR	Commissioned Officer
OR	odds ratio
OR	Other Ranks
OSU TBI-ID	Ohio State University Traumatic Brain Injury Identification Method
PBS	Pharmaceutical Benefits Scheme
PCL-C	Posttraumatic Stress Disorder Checklist – civilian version
PCS	post-concussive symptoms
PCS	Post-concussion Syndrome Checklist
PGSI	Problem Gambling Severity Index
PHQ-9	Patient Health Questionnaire-9
PMKeyS	Personnel Management Key Solution
PTSD	posttraumatic stress disorder
qEEG	quantitative electroencephalography
RPBS	Repatriation Pharmaceutical Benefits Scheme
SAC	Scientific Advisory Committee
SE	standard error
SIL-2RA	soluble interleukin-2 receptor alpha
TBI	traumatic brain injury
UA	University of Adelaide
WHO	World Health Organization

Glossary

12-month prevalence. Meeting diagnostic criteria for a lifetime ICD-10 mental disorder and then having reported symptoms in the 12 months before the interview.

Affective disorders. A class of mental health disorders. The Mental Health and Wellbeing Transition Study examined three types of affective disorder: depressive episodes, dysthymia and bipolar affective disorder. A central feature of these mental disorders is mood disturbance.

Agoraphobia. Marked fear or avoidance of situations such as crowds, public places, travelling alone or travelling away from home, which is accompanied by palpitations, sweating, shaking or dry mouth as well as other anxiety symptoms such as chest pain, choking sensations, dizziness and sometimes feelings of unreality, fear of dying, losing control or going mad.

Alcohol dependence. Characterised by an increased prioritisation of alcohol in a person's life. The defining feature is a strong, overwhelming desire to use alcohol despite experiencing a number of associated problems. A diagnosis was given if the person reported three or more of the following symptoms in the preceding 12 months:

- a strong and irresistible urge to consume alcohol
- a tolerance to the effects of alcohol
- an inability to stop or reduce alcohol consumption
- withdrawal symptoms upon cessation or reduction of alcohol intake
- continuing to drink despite it causing emotional or physical problems
- reduction in important activities because of or in order to drink.

Alcohol harmful use. Diagnosis requires not only high levels of alcohol consumption but also that the alcohol use is damaging to the person's physical or mental health. Each participant was initially asked if they consumed 12 or more standard alcoholic drinks in a 12-month period. If so, they were then asked a series of questions about their level of consumption. A diagnosis of alcohol harmful use was applied if the alcohol interfered with work or other responsibilities, caused arguments with their family or friends, was consumed in a situation where the person could be hurt, resulted in being stopped or arrested by police, or if the participant continued to consume alcohol despite experiencing social or interpersonal problems as a

consequence of their drinking during the preceding 12-months. A person could not meet criteria for alcohol harmful use if they met criteria for alcohol dependence.

Alcohol Use Disorders Identification Test (AUDIT). Alcohol consumption and problem drinking were examined using the Alcohol Use Disorders Identification Test (Saunders et al., 1993), a brief self-report screening instrument developed by the World Health Organization. This instrument consists of 10 questions designed to examine the quantity and frequency of alcohol consumption, possible symptoms of dependence, and reactions or problems related to alcohol. The AUDIT is widely used in epidemiological and clinical practice for defining at-risk patterns of drinking.

Anxiety disorders. A class of mental health disorder that involves the experience of intense and debilitating anxiety. The anxiety disorders covered in the survey were panic attacks, panic disorder, social phobia, specific phobia, agoraphobia, generalised anxiety disorder, posttraumatic stress disorder and obsessive–compulsive disorder.

Australian Bureau of Statistics. Australia's national statistical agency, providing trusted official statistics on a wide range of economic, social, population and environmental matters of importance to Australia. To enable comparison of estimates in the Transitioned ADF with an Australian Community population, direct standardisation was applied to estimates in the 2014–2015 ABS National Health Survey data. The National Health Survey is the most recent in a series of Australia-wide ABS health surveys, assessing various aspects of the health of Australians, including long-term health conditions, health risk factors and health service use.

Australian Defence Force. The ADF, or Defence, is constituted under the *Defence Act 1903* (Cth). Its mission is to defend Australia and its national interests. In fulfilling this mission, Defence serves the government of the day and is accountable to the Commonwealth Parliament, which represents the Australian people, to efficiently and effectively carry out the Government's defence policy. The Transition and Wellbeing Research Programme seeks to examine the mental, physical and social health of Serving and Ex-Serving Australian Defence Force members and their families. It builds on previous research to inform effective and evidence-based health service provision for contemporary service members and veterans.

Australian Institute of Family Studies. The Australian Government's key research body in the area of family wellbeing, AIFS conducts original research to increase understanding of Australian families and the issues that affect them. The current research was conducted by a consortium of Australia's leading research institutions led by the Centre for Traumatic Stress Studies at the University of Adelaide and AIFS.

Australian Institute of Health and Welfare. Australia's national agency for health and welfare statistics and information. It was used in this Programme to develop a Study Roll by integrating contact information from various sources and databases.

Bipolar affective disorder. A class of mental disorder associated with fluctuations of mood that are significantly disturbed. These fluctuations of mood can be markedly elevated on some occasions (hypomania or mania) and markedly lowered on other occasions (depressive episodes). A diagnosis of bipolar affective disorder was applied in this study if the individuals met criteria for mania or hypomania in the preceding 12 months.

Centre for Traumatic Stress Studies. This centre, at the University of Adelaide, seeks to improve evidence-based practice by informing and applying scientific knowledge in the field of trauma, mental disorder and wellbeing in at-risk populations. The current research was conducted by a consortium of Australia's leading research institutions led by the CTSS and the Australian Institute of Family Studies.

Chain of command. A line of authority and responsibility along which orders are passed within a military unit and between different units.

Class of mental disorder. Mental disorders are grouped into classes of disorder that share common features. Three classes of mental disorder were included in the survey – affective disorders, anxiety disorders and alcohol disorders.

Comorbidity. The occurrence of more than one disorder at the same time. Comorbidity was defined by grouping any alcohol disorders, any affective disorders, any anxiety disorders (excluding PTSD) and PTSD according to their co-occurrence. In addition to a breakdown of the individual patterns of co-occurrence, five categories were defined, representing those with no mental health disorder and those with one, two, three or four disorder categories.

Composite International Diagnostic Interview (CIDI). The World Mental Health Survey Initiative version of the World Health Organization's Composite International Diagnostic Interview, version 3 (WMH-CIDI 3.0)(Kessler & Ustun, 2004) provides an assessment of mental disorders based on the definitions and criteria of two classification systems – the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) and the World Health Organization International Classification of Diseases, 10th revision (ICD-10) (World Health Organization, 1994). This instrument was used in phase 2 of the Research Programme.

Confidence interval. This measurement gives an estimated range of values that is likely to include an unknown population parameter, the estimated range being calculated from a given set of sample data.

Department of Veterans' Affairs. DVA delivers government programs for war veterans and members of the ADF and the Australian Federal Police and their dependants. In 2014, DVA, in collaboration with the Department of Defence, commissioned the Transition and Wellbeing Research Programme, one of the largest and most comprehensive military research projects undertaken in Australia.

Deployment trauma. This can be referred to as traumatic deployment exposure, traumatic events that occur on deployment, deployment-related trauma, combat exposure or war-related trauma.

Deployment status. The Mental Health and Wellbeing Transition Study defined deployment status, based on survey responses, as:

- *Never deployed.* Individuals who did not endorse any deployments listed in the self-report survey (Your Military Career: Deployments) and did not endorse any deployment exposures (Your Military Career: Deployment Exposure).

- *Deployed.* Individuals who endorsed one or more of the listed deployments (Your Military Career: Deployments) or endorsed one or more of the deployment exposures (Your Military Career: Deployment Exposure).

Depressive episodes. Characteristic of a major depressive disorder, a depressive episode requires that an individual has suffered from depressed mood lasting a minimum of two weeks, with associated symptoms or feelings of worthlessness, lack of appetite, difficulty with memory, reduction in energy, low self-esteem, concentration problems and suicidal thoughts. Depressive episodes can be mild, moderate or severe. All three are included here under the same heading. Hierarchy rules were applied to depressive episodes, such that a person could not have met criteria for either a hypomanic or a manic episode.

Diagnostic criteria. The survey was designed to estimate the prevalence of common mental health disorders defined according to clinical diagnostic criteria, as directed by the International Classification of Diseases 10th Revision (ICD-10). Diagnostic criteria for a disorder usually involve specification of the following:

- the nature, number and combination of symptoms

- the period over which the symptoms have been continuously experienced

- the level of distress or impairment experienced

- the circumstances for exclusion of a diagnosis; for example, it being due to a general medical condition or the symptoms being associated with another mental disorder.

Dimensions of Anger Reactions Scale (DAR-5). A concise measure of anger consisting of five items covering anger frequency, intensity, duration, aggression and interference with social functioning. Items are scored on a five-point Likert scale, generating a severity score ranging from 5 to 25, with higher scores indicating worse symptomatology. This scale has been used previously to assess Australian Vietnam veterans, as well as US Afghanistan and Iraq veterans, and shows strong unidimensionality and high levels of internal consistency and criterion validity.

DVA client. A term used when referring to DVA clients for the purpose of analysis. In the construction of the DVA dataset for the Study Roll, DVA created an indicator of confidence against each veteran with respect to the level of interaction DVA had with them for assessing how confident DVA was about the accuracy of their address. Members of each of the following groups were considered DVA clients:

- *High.* Where a veteran is in receipt of a fortnightly payment (such as income support or a compensation pension) from DVA it was a sign of regular ongoing contact with the client and therefore DVA would have a high level of confidence that their address would be up to date and correct.

- *Medium.* Where a veteran only holds a treatment card (that is, does not also receive an ongoing payment) there is a lower level of ongoing contact with the department and therefore the level of confidence DVA can assign to the accuracy of the client's address is lower.

- *Low.* Not all veterans who have their illness/injury liability claim accepted as service related by DVA automatically receive a treatment card or pension payment, yet they would still be considered DVA clients.

For the purposes of this report, any individual in the study population who met the criteria just listed was flagged as a 'DVA client'. Those with this flag were compared against those without this flag.

Dysthymia. Characterised as a chronic or pervasive disturbance of mood lasting several years that is not sufficiently severe or in which the depressive episodes are not sufficiently prolonged to warrant a diagnosis of a recurrent depressive disorder. Hierarchy rules were applied to dysthymia such that, to have this disorder, a person could not have met criteria for either a hypomanic or manic episode and could not have reported episodes of severe or moderate depression within the first two years of dysthymia.

Ex-service organisation. Organisations that provide assistance to current and former ADF members. Services can include but are not necessarily limited to welfare support, help with DVA claims, and employment programs and social support.

Generalised anxiety disorder. A generalised and persistent worry, anxiety or apprehension about everyday events and activities lasting a minimum of six months and accompanied by anxiety symptoms as described for 'agoraphobia'. Other symptoms can be symptoms of tension (such as inability to relax and muscle tension) and other non-specific symptoms (such as irritability and difficulty concentrating).

Generalised Anxiety Disorder 7-item Scale (GAD-7). A brief screening measure based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) criteria for generalised anxiety disorder. Originally validated for use in primary care, the GAD-7 performs well in detecting probable cases of the disorder, with a sensitivity of 89% and a specificity of 82%.

Gold Card. A DVA health card for all conditions. Gold Card holders are entitled to DVA funding for services for all clinically necessary healthcare needs and all health conditions, whether or not they are related to war service. The card holder may be a veteran or the widow/widower or dependant of a veteran. Only the person named on the card is covered.

Help-seeking latency. The delay in time between first becoming concerned about a health problem and first seeking help for that problem. To assess help-seeking latency in the study, participants were asked to indicate when they first sought help for their own mental health. Options included 'within three months of becoming concerned' or 'within one year of becoming concerned'. Alternatively, participants were able to specify the number of years since becoming concerned. This item was developed by researchers for use in the study.

Hypomanic episodes. Episodes that last at least four consecutive days and are considered abnormal to the individual. These episodes are characterised by increased activity, talkativeness, elevated mood, disrupted concentration, decreased need for sleep and disrupted judgment manifesting as risk-taking (for example, mild spending sprees). In a subgroup of people, these disorders are particularly characterised by irritability. To meet criteria for the 'with hierarchy' version, the person cannot have met criteria for an episode of mania.

Index deployment. The MEAO Prospective Study surveyed and tested participants before and after a deployment that occurred between 2010 and 2012. This is referred to as the 'index deployment'.

Kessler Psychological Distress Scale (K10). A short 10-item screening questionnaire that yields a global measure of psychological distress based on symptoms of anxiety and depression experienced in the most recent four-week period. Items are scored from 1 to 5 and are summed to give a total score between 10 and 50. Various methods have been used to stratify the scores of the K10. The categories of low (10–15),

moderate (16–21), high (22–29) and very high (30–50) that are used in this report are derived from the cut-offs of the K10 that were used in the 2007 Australian Bureau of Statistics National Survey of Mental Health and Wellbeing (Slade et al., 2009).

Lifetime prevalence. A prevalence that meets diagnostic criteria for a mental disorder at any point in the responder's lifetime.

Lifetime trauma. Exposure questions used in this study were drawn from the posttraumatic stress disorder module of the CIDI (Haro et al., 2006). Participants were asked to indicate whether or not they had experienced the following traumatic events: combat (military or organised non-military group); being a peacekeeper in a war zone or a place of ongoing terror; being an unarmed civilian in a place of war, revolution, military coup or invasion; living as a civilian in a place of ongoing terror for political, ethnic, religious or other reasons; being a refugee; being kidnapped or held captive; being exposed to a toxic chemical that could cause serious harm; being in a life-threatening automobile accident; being in any other life-threatening accident; being in a major natural disaster; being in a man-made disaster; having a life-threatening illness; being beaten by a spouse or romantic partner; being badly beaten by anyone else; being mugged, held up or threatened with a weapon; being raped; being sexually assaulted; being stalked; having someone close to you die; having a child with a life-threatening illness or injury; witnessing serious physical fights at home as a child; having someone close experience a traumatic event; witnessing someone badly injured or killed or unexpectedly seeing a dead body; accidentally injuring or killing someone; purposefully injuring, torturing or killing someone; seeing atrocities or carnage such as mutilated bodies or mass killings; experiencing any other traumatic event.

Mania. Similar to hypomania but more severe in nature. Lasting slightly longer (a minimum of a week), these episodes often lead to severe interference with personal functioning. In addition to the symptoms outlined under 'hypomania', mania is often associated with feelings of grandiosity, marked sexual indiscretions and racing thoughts.

Medical Employment Classification. An administrative process designed to monitor physical fitness and medical standards in the ADF. MEC was divided into four levels (either current or on discharge from Regular ADF service):

- *MEC 1.* Members who are medically fit for employment in a deployed or seagoing environment without restriction.

- *MEC 2.* Members with medical conditions that require access to various levels of medical support or employment restrictions. They remain, however, medically fit for duty in their occupation in a deployed or seagoing environment. In allocating

sub-classifications of MEC 2, access to the level of medical support will always take precedence over specified employment restrictions.

- *MEC 3.* Members who are medically unfit for duty in their occupation in a deployed or seagoing environment. The member so classified should be medically managed towards recovery and should be receiving active medical management with the intention of regaining MEC 1 or 2 within 12 months of allocation of MEC 3. After a maximum of 12 months their MEC is to be reviewed. If still medically unfit for military duties in any operational environment, they are to be downgraded to MEC 4 or, if appropriate, referred to a Medical Employment Classification Review Board for consideration of an extension to remain MEC 3.

- *MEC 4.* Members who are medically unfit for deployment or seagoing service in the long term. Members who are classified as MEC 4 for their military occupation will be subject to review and confirmation of their classification by a Medical Employment Classification Review Board.

Medical fitness. A status defined as follows:

- *Fit.* Those who are categorised as fully employable and deployable or deployable with restrictions. Participants are classified as 'fit' if they fall into MEC 1 or 2, as described, or are assigned a perturbed MEC value of 'fit'.

- *Unfit.* Those not fit for deployment, their original occupation and/or further service. This can include those undergoing rehabilitation or transitioning to alternative return-to-work arrangements or in the process of medically separating from the ADF. Participants were classified as 'unfit' if they fell into MEC 3 or 4, as described, or were assigned a perturbed MEC value of 'unfit'.

Medical discharge. The involuntary termination of the client's employment by the ADF on the grounds of permanent or at least long-term unfitness to serve or unfitness for deployment to operational (warlike) service.

Mental health disorders. Defined according to the detailed diagnostic criteria in the World Health Organization International Classification of Diseases. This publication reports data for ICD-10 criteria.

Mental Health Prevalence and Wellbeing Study. This 2010 study is part of the Military Health Outcomes Program, or MilHOP, the first comprehensive investigation of the mental health of serving ADF members.

Middle East Area of Operations. Australia's military involvement in Afghanistan and Iraq is often referred to as the Middle East Area of Operations, or MEAO. Thousands of members have deployed to the MEAO since 2001, with many completing multiple

tours of duty. The Transition and Wellbeing Research Programme builds on the Military Health Outcomes Program, which detailed the prevalence of mental disorder in service women and men.

Military Health Outcomes Program. MilHOP detailed the prevalence of mental disorders among serving ADF members in 2010 as well as deployment-related health concerns for those deployed to the Middle East Area of Operations. The Transition and Wellbeing Research Programme addresses a number of gaps identified following MilHOP, including the mental health of Reservists, Ex-Serving members and ADF members in high-risk roles, as well as the trajectory of disorder and pathways to care for individuals identified as having a mental disorder in 2010.

National Death Index. A Commonwealth database that contains records of deaths registered in Australia since 1980. Data come from the Registry of Births, Deaths and Marriages in each jurisdiction, the National Coronial Information System and the Australian Bureau of Statistics. Before potential participants were contacted, the Study Roll was cross-checked against the NDI to ensure we did not attempt to approach deceased members.

National Health and Medical Research Council. Australia's peak funding body for medical research. The NHMRC has funded previous investigations undertaken by the Centre for Traumatic Stress Studies.

National Health Survey. The 2014–15 National Health Survey is the most recent in a series of Australia-wide Australian Bureau of Statistics health surveys, assessing various aspects of the health of Australians, including long-term health conditions, health risk factors and health service use.

Obsessive–compulsive disorder. A disorder characterised by obsessional thoughts (ideas, images, impulses) or compulsive acts (ritualised behaviour). These thoughts and acts are often distressing and typically cannot be avoided, despite the sufferer recognising their ineffectiveness.

Optimal epidemiological cut-off. The value that brings the number of false positives (mistaken identifications of a disorder) and false negatives (missed identifications of a disorder) closest together, thereby counterbalancing these sources of error most accurately. Therefore, this cut-off would give the closest estimate to the true prevalence of a 30-day ICD-10 disorder as measured by the CIDI and should be used to monitor disorder trends.

Optimal screening cut-off. The value that maximises the sum of sensitivity and specificity (the proportion of those with and without a disease who are correctly classified). This cut-off can be used to identify individuals who might need further care.

Panic attack. Sudden onset of extreme fear or anxiety, often accompanied by palpitations, chest pain, choking sensations, dizziness, and sometimes feelings of unreality, fear of dying, losing control or going mad.

Panic disorder. Recurrent panic attacks that are unpredictable in nature.

Patient Health Questionnaire-9. Self-reported depression was examined using the Patient Health Questionnaire-9, or PHQ-9. The nine items of the PHQ-9 are scored from zero to 3 and summed to give a total score between zero and 27. The PHQ-9 provides various levels of diagnostic severity, with higher scores indicating higher levels of depression symptoms.

Pharmaceutical Benefits Scheme. The PBS began as a limited scheme in 1948, offering free medicines for pensioners and a list of 139 'life-saving and disease-preventing' medicines free to other members of the community. Today, the PBS provides timely, reliable and affordable access to necessary medicines for all Australians. It is part of the Australian Government's broader National Medicines Policy. Healthcare use and cost, and Pharmaceutical Benefits Scheme data and Repatriation Pharmaceutical Benefits Scheme data were obtained for consenting Serving and Ex-Serving ADF members as part of the Research Programme.

Posttraumatic stress disorder. PTSD is characterised by a stress reaction to an exceptionally threatening or traumatic event that would cause pervasive distress in almost anyone. Symptoms are categorised into three groups – re-experiencing memories or flashbacks, avoidance symptoms, and either hyperarousal symptoms (increased arousal and sensitivity to cues) or inability to recall important parts of the experience.

The Posttraumatic Stress Disorder Checklist – civilian version (PCL-C). A 17-item self-report measure designed to assess the symptomatic criteria of PTSD according to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV). The 17 questions of the PCL-C are scored from 1 to 5 and are summed to give a total symptom severity score of between 17 and 85. An additional four items from the newly released PCL-5 were also included, giving researchers flexibility to also measure PTSD symptoms according to the most recent definitional criteria.

Personnel Management Key System (PMKeyS). An integrated human resource management system that provides for the ADF a single source of personnel management information. PMKeyS manages information about the entire Defence workforce – Navy, Army, Air Force.

Prevalence of mental disorders. The proportion of people in a given population who meet diagnostic criteria for any mental disorder in a given time frame. (See also '12-month prevalence' and 'lifetime prevalence'.)

Probable mental disorder. Where probable rates of mental health disorder are presented, these are based on self-report epidemiological cut-offs.

Psychopathology. The scientific study of mental disorders.

Rank status. Three levels of rank were used in the Mental Health and Wellbeing Transition Study:

- *Commissioned Officer (OFFR).* Senior Commissioned Officers (Commander (CMDR), Lieutenant Colonel (LTCOL), Wing Commander (WGCDR) and above) and Commissioned Officers (Lieutenant Commander (LCDR), Major (MAJ), Squadron Leader (SQNLDR) and more junior ranks).

- *Non-Commissioned Officer (NCO).* Senior Non-Commissioned Officers (Petty Officer (PO), Sergeant (SGT) and more senior ranks), and Junior Non-Commissioned Officers (Leading Seaman (LS), Corporal (CPL) and more junior ranks).

- *Other Ranks.* Able Seaman (AB), Seaman (SMN), Private (PTE), Leading Aircraftman (LAC), Aircraftman (AC) or equivalent.

Reason for discharge. The reason for transitioning out of the ADF. In the Research Programme the reason for discharge was derived from responses to the self-report survey and classified thus:

- *Medical discharge.* Involuntary termination of the client's employment by the ADF on the grounds of permanent or at least long-term unfitness to serve or unfitness for deployment to operational (war-like) service.

- *Other.* All other types of discharge, including compulsory age retirement, resignation at own request, assessed as unsuitable for further training, end of fixed-period engagement, end of initial enlistment period or return of service obligation, end of limited-tenure appointment, not offered re-engagement, accepted voluntary redundancy, compassionate grounds, and non-voluntary administrative discharge.

Repatriation Pharmaceutical Benefits Scheme. The benefits listed in the RPBS can be prescribed only for Department of Veterans' Affairs beneficiaries who hold a Gold, White or Orange Card. Healthcare use and cost, and Pharmaceutical Benefit Scheme data and Repatriation Pharmaceutical Benefits Scheme data were obtained for

consenting Serving and Ex-Serving ADF members as part of the current Research Programme.

Service status. The ADF consists of the following Services:

- *Royal Australian Navy.* A maritime force that contributes to regional security, supports global interests, shapes the strategic environment and protects national interests.

- *Australian Army.* The military land force, a potent, versatile and modern army that contributes to the security of Australia, protecting its interests and people.

- *Royal Australian Air Force.* An air force that provides immediate and responsive military options across the spectrum of operations as part of a whole-of-government joint or coalition response, either from Australia or on deployment overseas. It does this through its key air power roles – control of the air; precision strikes; intelligence, surveillance and response; and air mobility – enabled by combat and operational support.

Social phobia. The marked fear or avoidance of being the centre of attention or in situations where it is possible to behave in a humiliating or embarrassing way, accompanied by anxiety symptoms, as well as either blushing, fear of vomiting, or fear of defecation or micturition.

Specific phobia. The marked fear or avoidance of a specific object or situation (such as animals, birds, insects, heights, thunder, flying, small enclosed spaces, the sight of blood or injury, injections, dentists or hospitals) accompanied by anxiety symptoms as described for 'agoraphobia'.

Stratification. Grouping outcomes by variables of interest. In the *Mental Health Prevalence Report*, 12-month diagnosable mental disorder and self-reported suicidality were stratified by age, sex, rank, Service, years of service in the Regular ADF, deployment status, transition status, years since transition, reason for transition and DVA client status.

Study Roll. Participants' contact details and demographic information were obtained via the creation of a Study Roll by the Australian Institute of Health and Welfare. This process involved integrating contact information from the following sources:

- the Defence Personnel Management Key System database

- DVA client databases

- the National Death Index

- the ComSuper member database

- the Military Health Outcomes Program (MilHOP) dataset.

Subsyndromal disorder. Characterised by or exhibiting symptoms that are not severe enough for diagnosis as a clinically recognised syndrome.

Suicidal ideation. Serious thoughts about taking one's own life.

Suicidality. Suicidal ideation, suicide plans and attempts.

Transitioned ADF members. ADF members who have left military service. For the purpose of the current study, this included all ADF members who transitioned from the Regular ADF between 2010 and 2014, including those who transitioned into the Active Reserve and Inactive Reserve.

Transitioned status. Transitioned ADF members were categorised into one of three groups, which broadly represented their level of continued association and contact with Defence and their potential access to support services provided by Defence:

- *Ex-Serving.* A person who was a Regular ADF member before 2010, has since transitioned out of the ADF and is no longer engaged with Defence in a Reservist role. The individual is classified as discharged from Defence.

- *Inactive Reservist.* A person who was a Regular ADF member before 2010 but has since transitioned into an Inactive Reservist role.

- *Active Reservist.* A person who was a Regular ADF member before 2010 but has since transitioned into an Active Reservist role.

Two-phase design. A well-accepted epidemiological approach to investigating the prevalence of mental disorders. In the first phase of this study participants completed a screening questionnaire, which was generally economical in terms of time and resources. Based on the results of this screening and the demographic information provided, certain participants were selected for a more accurate but costly formal diagnostic interview.

Veterans' health cards. DVA, on behalf of the Australian Government, uses health cards as a convenient method for veterans, war widows and their eligible dependants to gain access to health and other care services. Arrangements are based on providing access to clinically appropriate treatment that is evidence-based. There are Gold, White and Orange Cards.

Weighting. Allowing for the inference of results for the entire population. Weighting for this study involved allocating a representative value or 'weight' to the data for each responder, based on key variables. The weight indicated how many individuals in the entire population were represented by each responder. Weighting was applied to:

- correct for differential non-response

- adjust for any systematic biases in the responders (for example, oversampling of high scorers for the CIDI).

White Card. A DVA health card for specific conditions. A White Card entitles the holder to care and treatment for:

- injuries or conditions that are accepted as being caused by war or service related

- malignant cancer, pulmonary tuberculosis, posttraumatic stress disorder, anxiety and/or depression, whether or not it was caused by war

- symptoms of unidentifiable conditions that arise within 15 years of service (other than peacetime service).

Services covered by a White Card are the same as those for a Gold Card but must be for treatment of conditions that are accepted as being caused by war or service related.

World Mental Health Survey Initiative Version of the World Health Organization Composite International Diagnostic Interview – version 3 (CIDI). The CIDI (Kessler & Ustun, 2004) provides an assessment of mental disorders based on the definitions and criteria of two classification systems: the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) and the International Statistical Classification of Diseases and Related Health Problems – 10th Revision (ICD-10) (World Health Organization, 1994). This instrument was used in phase 2 of the Research Programme.

Years since transition. To ascertain the number of years since transition from Regular Service, participants were asked to indicate what year they transitioned to Active Reserves or Inactive Reserves or were discharged out of the Service (Ex-Serving). Options were zero, one, two, three, four or five years.

Years of Regular Service. Six categories were used in the Mental Health and Wellbeing Transition Study to define the number of years of Regular Service: 3 months – 3.9 years, 4–7.9 years, 8–11.9 years, 12–15.9 years, 16–19.9 years and 20+ years.

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