From Department of Neuroscience
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STRESS IN MILITARY SETTINGS

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Stockholm 2024

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Published by Karolinska Institutet.
Printed by Universitetsservice US-AB, 2024

ISBN **978-91-8017-332-2**
Cover illustration: Private photo from Mali 2017

Stress in Military settings

Thesis for Doctoral Degree (Ph.D.)

By

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The thesis will be defended in public at Karolinska Institutet, Lecture Hall Eva and Georg Klein, 2024 06 18, 09:00.

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I dedicate this thesis to all peacekeeping Veterans out there

who is contributing to a better world.

Popular science summary of the thesis

Stress in military settings.

What constitutes a military setting, and why is it an intriguing subject for research?

In this thesis, I will present the findings from five studies covering three distinct areas: stress, brain injury, and cognition. The cognition aspect represents cognitive performance, which, alongside mental health, forms the core focus of the thesis. As you will discover, I strongly advocate for research that adopts an operational approach, meaning research based on actual needs or inquiries originating from the military, and performed within the regular operational or training environment. Two of the studies stems from direct requests from military units, while two other studies are born out of my ambition to formalize years of experience gained from working in the field. It's not always sufficient to rely solely on experiential knowledge; we need to reinforce or validate it with scientific methods to overcome potential personal biases. The fifth study is a collaboration with researchers from the Defense Veteran Brain Injury Centre in Washington, a study that has its origin not directly from the military (as the other four studies) but from questions emerging in field of brain injury in general, were the military can have data that the civilian populations lacks.

When researching stress in military settings, there are several questions that we need to address. Can we assess stress during deployment, using self-evaluation? Is there objective measures that can be useful? Can we predict who will react more or less to stress? Should we tailor homecoming and follow-up programs based on our findings etc?

Military stress is not limited to deployment, it is also present during training. Aside from deployments we studied personnel during conduct after capture training, a training that is intentionally stress provoking. Participants undergo a mock capture scenario exposing them to intensive stress. This stress triggers physiological reactions such as increased cortisol secretion and places a heavy burden on cognitive capacity affecting the way we process information. Both cortisol secretion and cognitive capacity are outcomes that we can assess, using objective measures.

Apart from psychological stress, this thesis delves into areas such as biomarkers for neurotrauma. Neurotrauma refers to injury to the central nervous system, primarily the brain itself. During deployments, blast-related injuries are common even during peacekeeping missions. Explosive devices, mortars, grenades, mines, etc., have caused to what is termed the signature wound of asymmetric warfare: traumatic brain injury (TBI) or mild traumatic brain injury (mTBI). The blast exposure with the potential to cause mTBI is also a form of stressor, that we refer to as physiological stress.

Some concepts used in this thesis might need an explanation. Let’s start with stress! Stress is a widely recognized concept, often associated with having too much to do and too little time to do it. We also experience stress in situations like public speaking or taking important tests. However, stress encompasses more than these scenarios. The term "stress" was introduced in psychology by Hans Selye in 1936, originally borrowed from physics to describe load on materials and structures. In this sense, it's a suitable term, as it refers to the load on an organism, such as a human. Stress is ever-present and serves as the "load" or the activator that propels us forward. There are some key models related to stress worth mentioning. One is homeostasis, a state of balance where optimal levels of bodily functions are maintained. For example, dehydration triggers a stress response, leading to thirst, which, when quenched, restores balance. Homeostasis also pertains to blood oxygenation, pH, body temperature, and other physiological processes with relatively narrow functional span and fluctuations. Another concept related to stress is allostasis, an adaptive process that activates our sympathetic nervous system to cope with threats and challenges. It goes beyond maintaining internal balance and activates when facing threats, then deactivates when the threat subsides. Allostasis affects the Hypothalamus-Pituitary-Adrenal axis, initiating the release of stress-related hormones such as cortisol, adrenaline, and noradrenaline. While stress is primarily a physiological process, it is triggered by a psychological perception of our environment. There doesn't have to be an objective threat; a perceived or anticipated threat can also induce a stress response, leading to the commonly known fight-or-flight (or freeze) response. When faced with stress, we react in various ways, some adaptive and others maladaptive. One model, the Yerkes-Dodson law, or the inverted U shape of stress and performance, proposes that optimal stress levels produce optimal performance, with performance declining beyond a certain point of stress intensity (overload). This law forms the basis for conduct after capture training. The stress experienced during conduct after capture training should be sufficient to surpass the peak of the inverted U shape, providing enough stress to form a challenge, without overloading it excessively. This challenge should be hard enough to slightly impede action, leading to increased confidence and capacity to handle similar stress in real-life situations when the situation is successfully managed. This approach is termed stress inoculation training, and proven valuable by personnel who have undergone capture experiences.

Apart from stress, we have focused on brain injury. Why? Despite the shift from asymmetric warfare and use of improvised explosive devices (IEDs), towards more traditional warfare, blast-related injuries remain prevalent. Expolsives carried in military drones, artillery, rockets, and missiles pose significant risks for brain injury. These injuries result from acceleration injury, focal injury (penetrating violence), and blast waves. They can cause internal tearing in the brain when white and grey matter move independently, or cavitations when blast waves compress and stretch soft tissue. While our study primarily addresses mild traumatic brain injury (mTBI), caused by concussions, exposure to low-level blast waves from heavy weaponry during training also poses risks. While breacher training and exposure to low-level blast waves aren't normally causing concussion, amplified blasts may cause brain harm. In our study, blast exposure was measured using gauges worn on different body parts, with individuals recommended to avoid repeated exposure if gauges signaled excessive blast levels.

All studies, except the last one, involved active-duty personnel. The final study, a registry study, utilized data from US soldiers returning from Iraq or Afghanistan. Collaborating with the Defense and Veterans Brain Injury Center, we sought to investigate whether age at the time of the injury affects recovery. The brain matures slowly, reaching full functionality around 25 years of age, with the frontal lobes maturing. The study aimed to determine if injuries occurring before or after this age threshold would impact recovery, as measured by neuropsychological tests.

In summary, the findings from our studies support the notion that military deployment itself doesn't necessarily induce stress; in fact, it may alleviate certain stressors found at home. Deployment stress is dynamic and unpredictable, and pre-deployment stress not necessarily indicative of future reactions to objective stressors. In training scenarios where stress is desired, we can amplify it using methods such as sleep deprivation and inadequate nutrition. Additionally, training involving risk components, like exposure to low-level blast waves, only temporarily affects biomarkers for brain injury, with individuals recovering within days. The final study suggests that soldiers under 24 years of age experience less cognitive impairment following brain injury compared to older cohorts.

Abstract

Stress in the military reality is often related to either mental health or performance. When it comes to mental health, most of the literature is concerned with the possible negative effects from exposure to combat-related trauma or other stressors related to deployment. Performance, on the other hand, is more often related to training. In this thesis, both areas are addressed in the following 5 studies. In **Study I**, stress related to deployment was measured before, during, and after deployment. The results showed that stress was lower during deployment compared to before or after. The study aims to highlight that all deployments are unique and not by nature inherently stressful. **Study II** continues to target deployment; the study looks at the relevance of assessing stress and mental health before and during deployment to predict post-deployment mental health. The results showed no predictive value over time but some correlation between pre- and during-measures. Still, we found that mental health screening is relatively easy to do and provides relevant data on current mental health status. **Study III** and **Study IV** are focused on military-specific training. In **Study III**, we looked at stress assessed through cortisol measures and cognitive performance during a conduct after capture training course. The aim was to evaluate the effectiveness of the scenario aimed at stressing the participants. Results showed that the training was effective and that stress levels were multiplied during the exercise. During training, the subjects showed difficulties recalling and utilizing strategies that they were taught due to the intense stress. However, there was no effect on cognitive performance when assessed directly after, indicating a short recovery time for cognition from after being exposed to the stressors. **Study IV** concerns "Breaching"; during breacher training, the operator is exposed to low-level blast (LLB). In this study, we looked closer at two outcomes: biomarkers of brain injury and cognitive performance. The biomarkers show a reactive response. In direct conjunction with the blasts, returning to baseline when followed up a few days later. There were no effects on cognitive performance due to the LLB exposure. **Study V** is an international collaboration with the Defense and Veterans Brain Injury Centre in the US. In that study, we used registry data from soldiers returning from Iraq or Afghanistan. They were screened for Traumatic Brain Injury, chronic pain, and other disorders. The objective was to see if the age at onset of the injury had any impact on the type and magnitude of symptoms. The results suggest that the younger soldiers with a still maturing brain are more susceptible to frontal lobe-related

symptoms, while symptoms related to cognitive performance were slightly more noticeable in the older subjects. **Overall,** the thesis illustrates the importance of "measuring", to gain a valid assessment both for stress management preserving mental health and performance as well. Mental Health in the military is mostly related to post-deployment assessment rather than proactive actions, bringing health closer to performance can increase awareness of the need for stress management strategies.

List of scientific papers

I. Wisén, N., Larsson, G., Arborelius, U., & Risling, M. (2021). Are Peacekeeping Missions Inevitably Stressful? *Scandinavian Journal of Military Studies, 4*, 210–219. doi:http://doi.org/10.31374/sjms.107

II. Wisén, N., Larsson, G., Risling, M., & Arborelius, U. (2022). Measuring the Impact of Operational Stress: The Relevance of Assessing Stress-related Health Across the Deployment Cycle. *Military Medicine*. doi:10.1093/milmed/usab542

III. Wisén, N., Larsson, G., Risling, M., & Arborelius, U. (2022). Is conduct after capture training sufficiently stressful? [Original Research]. *Frontiers in psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.795759

IV. Wisén, N., Arborelius, U., Larsson, G., Kaj Blennow., Henrik Zetterberg & Risling, M. Exposure to low-level blast during breacher training. Possible effects on brain health and performance. *Manuscript*

V. Ivins, B., Risling, M., Wisén, N., Schwab, K., & Rostami, E. (2023). Mild Traumatic Brain Injury in the Maturing Brain: An Investigation of Symptoms and Cognitive Performance in Soldiers Returning From Afghanistan and Iraq. *The Journal of Head Trauma Rehabilitation*. doi:10.1097/htr.0000000000000919

Contents

List of abbreviations

ACTH	Adrenocorticotropic hormone
ANAM	Automated Neuropsychological Assessment Metrics
APA	American Psychology Association
AUC	Area Under the Curve
BBB	Blood brain barrier
CAC	Conduct after Capture
CAR	Cortisol Awakening Response
CBT	Cognitive Behavioral Therapy
CNS	Central Nervous System
CRF	Corticotropin releasing factor
CRH	Corticotropin releasing Hormone
DANA	Defense Automated Neurobehavioral Assessment
DHEA-s	Dehydroepiandrosterone
DVBIC	Defense and Veterans Brain Injury Centre
FÖS	Försvarets Överlevnadsskola
HPA-axis	Hypothalamic-pituitary-adrenal axis
IED	Improvised Explosive Device
IIV	Intra Individual Variability
KSQ	Karolinska Sleep Questionnaire
LLB	Low Level Blast
mTBI	Mild Traumatic Brain Injury
OEF	Operation Enduring Freedom (Afghanistan war 2001-2014)
OIF	Operation Iraqi Freedom (Iraq war 2003-2011)
PKO	Peacekeeping Operations
PTE	Potentially Traumatizing Event
PTSD	Post-Traumatic Stress Disorder

SERE	Survival, Evasion, Resistance, and Escape
SAM	Sympathetic-adreno-medullar axis
SIT	Stress Inoculation Training
SMBM	Shirom Melamed Burnout Measure.
SRT	Simple Reaction Time
TBI	Traumatic Brain Injury
TRFV	Task Related Fitness Value
UK	United Kingdom
UN	United Nations
US	United States

Introduction

Military psychology and stress in military settings are not new disciplines. As we can see in *Figure 1*. There have been many different explanations for why soldiers suffer mental injuries after war and trauma. However military psychology is far more than trauma related. During World War I, the field of assessment and selection of pilots emerged. A field that was developed even more during World War II, with new areas such as, aviation psychology, cognitive testing, and rehabilitation therapies (Hacker Hughes et al., 2019).

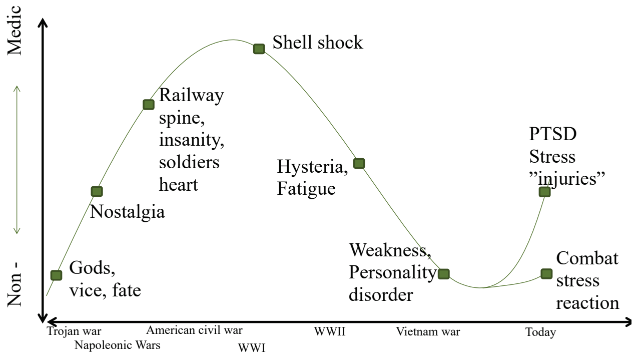

Figure 1. A description of the explanation of mental health issues related to war trauma, from a historical view.

Currently, the field of psychology has worked its way into various areas within the military, and it's even considered as a force multiplier(McCauley & Breeze, 2019). Development over the years has led to psychology being a valued component in pre deployment training (Flanagan et al., 2012; Mulligan et al., 2011; Sharpley et al., 2008), post deployment screening (Rona et al., 2017), support during deployment (Bliese et al., 2011) and during training.

There are several well-established international conferences in the field of military psychology: International Military Testing Association IMTA, International Applied Psychology Symposium IAMPS, the Div19 military psychology from American Psychology Association and the International Conference of Soldiers Physical Performance ICSPP, to name a few. Regardless of their names they have all cover different aspects of military psychology, and even when the name implies physical performance there is most often a substantial part devoted to cognitive function and performance, in relation to physical strain. Aside from individual performance the area of operational psychology targets groups and organizations. One definition of military psychology is that it is a specialty that applies behavioral science principles to more effectively understand, develop, target and /or influence an individual, group or organization to accomplish tactical, operational, or strategic goals (Staal & DeVries, 2020; Staal & Stephenson, 2013). Staal and colleagues argue the relevance of psychological consultation in areas such as: personnel screening, military training such as Survival, Evasion, Resistance, and Escape (SERE) training, and consultation to military operations. Psychological support in those areas should be based on experience in combination with science. Therefore, research psychology has its given place in the defense and security arena. As the way we fight changes along with new technology, new challenges on cognitive performance in various information processing processes become basic soldier skills. The capacities of soldiers and functional adaptions to technology needs to be researched and further developed (Butcher, 2019)

Military operational research and the overarching aim of this thesis is to delve into the nuanced dynamics of stress within military settings, focusing on the cognitive and physiological impacts on soldiers during both deployment and training environments. This work endeavors to bridge the gap between academic research and practical application, shedding light on how psychological principles can be effectively integrated into military operations to enhance soldier performance and wellbeing. To achieve this, the thesis is structured around the following specific objectives:

- To investigate the varying levels and impacts of stress experienced by soldiers before, during, and after deployment, with a focus on identifying factors that contribute to stress reduction and enhancement of mental resilience.
- To evaluate the effectiveness of current psychological support and training methods, such as Survival, Evasion, Resistance, and Escape (SERE) training, in preparing soldiers for the psychological challenges of military operations.
- To examine the relationship between stress and cognitive performance in military settings, identifying key areas where military training can be adapted to better support soldier cognitive health and operational efficiency.

- To explore the role of psychological research in developing strategies and interventions that can be practically applied in military contexts, thereby supporting the overall psychological readiness and operational effectiveness of military personnel.

By addressing these objectives, this thesis aims to contribute significantly to the field of military psychology, offering new insights and practical recommendations for enhancing the mental health and cognitive capabilities of soldiers in the line of duty. In doing so, the thesis will not only add to the academic discourse but also provide actionable guidance for military practitioners, ultimately aiming to improve the psychological support and training provided to those who serve.

1 Literature review

1.1 Stress

The psychological use of the concept of “stress” origins from the work of Hans Selye. He referred to stress as an agent (harmful, or poisonous) to the organism. He showed effects of both acute and cumulative stress on rats exposed to a *stressor* i.e. a *nocuous agent (Rom & Reznick, 2016; Selye, 1936)*. Other early models of stress such as *Homeostasis* based on theories by the French physiologist Claude Bernard, later conceptualized by Walter Cannon in 1932, descried the organisms strive for balance between the internal or external milieu. Later models such as the “stress cycle” incorporates both physiological stressors and psychological stressor and introduces coping, as a way to respond to a stressor (Reznick, 1989; Rom & Reznick, 2016).

Reactions to stress occur as an organism strives to adapt its internal processes to meet the perceived challenge, even though this process is adaptive while the stress is happening, it might cause a negative internal imbalance if the stress is sustained (Peters & McEwen, 2012). The term allostasis refers to the process of how an organism maintains physiological stability. A continuous elevated allostatic load from cumulative stress is known to affect both health and cognitive performance (Juster et al., 2010; Law & Clow, 2020; Lupien et al., 2007). Stress reactions are not limited to physical stressors such as homeostatic imbalance or *nocuous agents*; stress is also psychological. Psychological stress is caused by stressors that originate from “perceived” stressors (Lazarus, 1991, 1999). Perceived stressors can be ongoing, causing an acute stress reaction, or they can be anticipated, based on previous experience or expectations (James et al., 2023; Pulopulos et al., 2020; Sapolsky, 2015). The philosopher Seneca in the first century said that “we suffer more in our imagination than we do in real life” a phrase that illustrates how we tend to create new or fail to leave bothersome thoughts and experiences behind us. As mentioned, psychological stress is about how we perceive our environment and factors that potentially can impact us, not objective measures.

When an individual perceives that they have the resources at hand to manage demands, it mitigates stress, and if perceived insufficient it’s the opposite (Bates et al., 2013), but how does psychological stress affect the rest of the body?

There are several stages in the stress response, one of the first is the activation of risk/fear processes in the amygdala, which is involved in stress or threat processing. The amygdala interprets the stimuli that is perceived through our senses, or from our imagination, and if it perceives it as danger or potential danger, it sends it further to the hypothalamus. This is a process that is influenced by experience as well as expectations. Noteworthy is that prolonged experience even with low intensity stress from perceived threats, can cause changes in amygdala activity, size, and processing. A change that has implication on regulation of the stress response in a way that demonstrates that combat or perceived threat can have sustained consequences on neural responsivity (Geuze et al., 2012; van Wingen et al., 2011). When the hypothalamus receives a distress signal from the amygdala it activates several response systems.

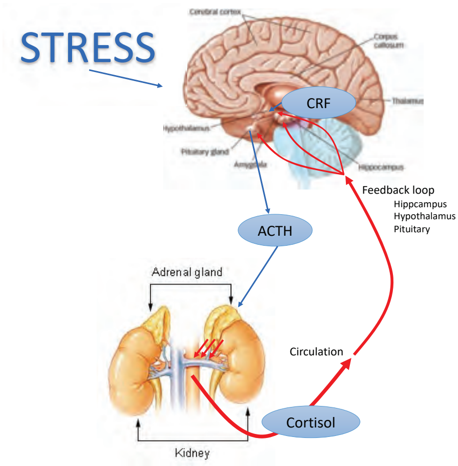

Figure 2. A schematic overview of the HPA-axis.

As described by Chu et al. there are two main processes or response pathways, one (fast response), that is the activation of the sympathetic nervous system that also activates the release of adrenaline from the adrenal medulla, named the sympathetic-adreno-medullar (SAM) axis. The second is the (slow response) the hypothalamus-pituitary-adrenal (HPA) axis The hypothalamus starts by releasing corticotropin-releasing-factor (CRF), which is interchangeably referred to as corticotropin-releasing-factor hormone (CRH) in the literature. In the pituitary the CRF triggers the release of adrenocorticotropin hormone (ACTH) in the bloodstream, and when it reaches the adrenals, it activates the adrenal cortex to release cortisol see *Figure 2*. The function of the HPA response to stress is to increase the capacity of the individual to perform on a more strenuous level than normal and face the stressor better. After the stress response, the systems normally returns to pre-arousal levels. (Chu et al., 2024). When exposed to prolonged stress i.e. cumulative stress it influences the release of stress hormones, such as cortisol over time usually in a positive relationship i.e. stress increase cortisol secretion, still a negative relationship is also seen as a consequence of prolonged stress, that is the cortisol response becomes blunted over time leading to lower levels (Clow et al., 2006; Makras et al., 2005). Cortisol is probably the most known and researched hormone in stress research; the effects on the body and brain of the stress response are described in depth by researchers such as McEwen and Lupien (Lupien et al., 2007; McEwen, 2013; McEwen et al., 2015; McEwen & Karatsoreos, 2015). Cortisol secretion from the adrenals follows a diurnal cycle with the highest levels present after waking up, a phenomenon termed the cortisol awakening response (CAR). During the day, cortisol levels fluctuate. Still levels related to waking up, are considered a relatively stable measure over time (Matsuda et al., 2012; Russell & Lightman, 2019; Wust et al., 2000). Over the course of the day, cortisol levels decline in a linear fashion, however, with fluctuations due to stress exposure. Daily fluctuations or intraindividual variability (IIV) occurs not only as direct reactions to stress (Schlotz et al., 2011), it could also be due to dysregulation of the HPA-axis or mental health issues (Lennartsson et al., 2015; Segerstrom et al., 2017). Since cortisol it easily accessed through noninvasive methods such as from saliva (Hellhammer et al., 2009; Kirschbaum & Hellhammer, 1989) and it can be collected even under operational or training conditions without disturbance.

1.2 Military Deployment

Military deployment-oriented psychology is often concerned with aversive effects such as traumatic stressors, combat, fear, exposure to atrocities, etc. (Committee on Gulf War and Health: Physiologic et al., 2008; Ferrier-Auerbach et al., 2010; Franz et al., 2013). Combat exposure is also the stressor that is closest related to deployment related mental health issues or distress (Brounéus, 2014; Inoue et al., 2024; Pietrzak et al., 2013; Sareen et al., 2007; Sareen et al., 2010; Waller et al., 2012). Deployment stress however is not limited to traumatic stressors or combat. There are everyday stressors that affects staff over time such as being away from home, a high workload, daily hassles, interpersonal relations etc. Those are stressors that accounts for a substantial part of deployment related stress (Forbes et al., 2016; Heron et al., 2013; Kaikkonen & Laukkala, 2016; Lyk-Jensen et al., 2016; Sareen et al., 2008; Sareen et al., 2007; Sareen et al., 2010).

It is not just stressors we can divide into categories. We also differentiate between combat missions and peacekeeping operations (PKO). In this thesis we target PKO. PKOs are not passive missions. Dag Hammarskjöld, the former UN

Secretary General, stated in one of his speeches that "peacekeeping is not a job for soldiers, but only soldiers can do it", implying that there both similarities and differences between PKO and combat operations (what soldiers are trained for). PKO are regulated with a mandate from the United Nations that regulates its use of force. One aspect that makes deployment related research challenging is that deployments vary, each mission has its own unique features (Bartone et al., 1998; Kaikkonen & Laukkala, 2016; Lande, 2014; Shigemura & Nomura, 2002). Deployment specifics must be considered when generalizing the results. In contrast to other research areas, results are not inevitably progressing i.e. building on previous research, and results studies from the 90's are still valid. Some studies found little or no support for mental health issues following deployment (Aux-Analysis., 2017, 2018; Fear et al., 2010; Jones et al., 2014). Other studies found support for a higher prevalence of mental health issues after deployment (Forbes et al., 2016; Heron et al., 2013; Lyk-Jensen et al., 2016; Sareen et al., 2008; Sareen et al., 2007; Waller et al., 2012), differences that illustrates the disparity of the field. Swedish studies related to deployment stress and mental health, has shown no significant increase in mental health issues (Michel et al., 2003).

The Swedish veteran population has been subjected to several registry studies where they have shown to be healthier than the general population (Aux-Analysis., 2018) and had lower rates of suicide than a matched group from the general population (Michel et al., 2007; Pethrus et al., 2017). Nationality and culture are factors that can't be neglected when interpreting the results. Modern Swedish soldiers have a good educational background, and the selection and basic training provides opportunity to identify individuals that lack the ability to manage stressful situations or harsh conditions. For comparison Denmark have a similar culture as Sweden, and both nations have experience of deploying soldiers to Afghanistan. Sweden in the northern part (Balkh province), with less combat exposure, and Denmark in the south (Helmand province), with high combat exposure. Danish studies have, contrary to the Swedish studies, found higher levels of mental health issues with the Danish veterans compared to Danish non-veterans (Lyk-Jensen et al., 2016). This show that even though culture might be argued as one relevant factor, it's still combat exposure, as mentioned in the introduction, that is one of the more prominent deployment stressors. (Álvares et al., 2020; Brounéus, 2014; Inoue et al., 2024; Pietrzak et al., 2013; Sareen et al., 2007; Sareen et al., 2010; Waller et al., 2012).

1.3 Military training

Military training is a broad term, and this thesis it deals with two different aspects: intentional effects and negative side effects. Intentional effects are the goal of the training like, skill acquisition, experience, knowledge, confidence etc. Negative side effects are unwanted outputs that can be avoidable or unavoidable. Avoidable side effects should be minimized or removed. Unavoidable side effects must be prepared for, and potentially harmful unavoidable effects must be risk managed and followed up after training. Since military training sometimes is made to mimic real life scenarios, they often contain unavoidable side effects due to their intense nature.

Survival evasion resistance escape training (SERE) is one of the most intense and challenging trainings in the military. It has been used not just for its main goal (survival skills) but also to study high stress exposure (Varanoske et al., 2022). Military survival programs have a long history, and during the 50:s US-Air force initiated programs to enhance strategies to master stress and maintain "major ego functions"(Genter, 2015). Modern SERE programs cover several training blocks such as conduct after capture (CAC). CAC builds on a stress inoculation training (SIT) model. SIT was developed in the 1980s based on cognitive behavioral therapy (CBT) models (Meichenbaum & Novaco, 1985). There is substantial evidence for the assumption that the SIT paradigm can be used to minimize adverse effects of stress on functional performance such as using learned strategies for survival (Matthew et al., 2015; Robson & Manacapilli, 2014). CAC training has been shown to be so stressful that they clearly affect hormones, such as DHEA-s and cortisol, as well as cognitive performance (Lieberman et al., 2016; Suurd Ralph et al., 2017). Therefore such training regimen needs to be balanced and functional (Flanagan et al., 2012).

The main stressor in CAC is psychological, in other training forms the stressor is more physical, such as exposure to blast waves during Breacher training. Breaching training is the use of explosives to make forceful or tactical entrance to buildings or rooms, to engage an enemy or rescue hostage as an example. During breacher training the trainee will be exposed to low level blast (LLB). Breaching is not the only military method that will expose soldiers/operators to LLB. Firing heavy artillery, grenade launchers and other weapon systems that are operated with staff relatively close to the blast will provide similar LLB exposure.

Officers being exposed to blast waves during repeated exposure from use of heavy weapon use report that they got concussion like symptoms (nausea, headache, fatigue). Still studies of that group showed little or no reactivity in neurochemical markers for injury during military training (Blennow et al., 2011). Other studies have shown negative effects from LLB in breacher training on neurocognitive performance (Carr et al., 2016; LaValle et al., 2019), and on biomarkers of neurotrauma (Tate et al., 2013). Some studies has argued that there might be acute health symptoms such as nausea, headache, slowed reaction time (Sajja et al., 2019) as well as long term health problems from repeated exposures (Kamimori et al., 2017). Results however are inconclusive and further studies are warranted.

Breacher training provides an opportunity to study LLB exposure in a controlled setting, gaining knowledge that can be relevant for assessment of potential injury due to operational LLB exposure in theater (Baker et al., 2011). Probably the most researched form of military training is military recruit training or special selection training where participants are expected to withdraw due to failure to complete the training. Those studies focus on fatigue and prolonged exposure to harsh conditions during that phase (Armstrong et al., 2023; Henning et al., 2011; Jouanin et al., 2004; Weeks et al., 2010). However military training often contains several stressful dimensions making it hard to know what factors that lies behind the results.

1.4 Cognition

American Psychological association (APA) defines cognition as: knowing and awareness, perceiving, remembering, reasoning, judging, imagining and problem-solving. Sometimes, it is referred to as executive functions that is planning and execution of plans. Cognition when treated as a functional resource is a part of what in the Swedish military is referred to as "stridsvärde" or Task Related Fitness Value (TRFV). Cognitions are an essential part in how we perceive, assess, make decisions and solving problems. In a military operative environment where one must make split-second decisions and perform in high stress situations, cognitive performance is essential.

Studies have shown a decrease in cognitive performance after deployment, mainly after periods of intense military stress (Lieberman, Bathalon, Falco, Morgan, et al., 2005; Lieberman et al., 2016; Vrijkotte et al., 2009). However some studies have shown the opposite, namely increased cognitive performance during/after deployment, possibly attributable to several factors, such as motivation and fighting spirit, factors that might function to protect against operational stress induced cognitive decline (Makhani et al., 2015).

Stress regardless of its source impacts cognition in several ways; one of first signs of cognitive impact from stress (intense or prolonged) is its effect on memory. As described, stress release cortisol to the bloodstream, in the brain it binds to two different receptor, Type I and Type II. Depending on the ratio between the two receptors there will be different impact on memory (Juster et al., 2010; Lupien et al., 2007). Kloet et al. did show that contrary to most literature where cortisol is described as having a negative effect on memory formation and retrieval, it can also have an enhancing effect. The negative maladaptive effects often come from prolonged exposure that change the saturation and ratio of the receptors in the brain while the positive comes from moderate momentary increased stress (Buchanan et al., 2006; de Kloet et al., 1999). Other aspects of cognition such as sustained focus, reasoning, problem-solving etc. can be impacted from the variety of load and strains that the military environment can provide (Harris et al., 2005; Lieberman, Bathalon, Falco, Kramer, et al., 2005; Lieberman et al., 2009; Lieberman et al., 2016; Lieberman et al., 2006; Suurd Ralph et al., 2017; Varanoske et al., 2022).

A more potentially serious impact on cognition is Traumatic Brain Injury (TBI) or when its less severe (concussion) mild Traumatic Brain Injury (mTBI). The TBI field is an extensive filed that lies beyond the scope of this thesis. Still, we need to define what TBI and mTBI is. TBI can be defined as an alteration in brain functioning or other evidence of brain pathology caused by an external force (Menon et al., 2010). mTBI, or concussion, is harder to define. Some argue that it can be defined by the use of the Glasgow Coma Scale or the presence of symptoms such as, less then 30 minutes consciousness, post traumatic amnesia or a transient neurological deficit (Lefevre-Dognin et al., 2021). Paper V deals with mTBI but the focus for study V is limited to the cognitive or neuropsychological aspects. Since mTBI and TBI often is sustained during a potentially traumatizing event (PTE) there is a close connection with post-traumatic stress disorder (PTSD). Some studies propose that they affect the same areas in the brain (Bogdanova & Verfaellie, 2012; Vasterling et al., 2009). Several studies on veterans target the challenge that the shared etiology (PTE and LLB) pose when it comes to health issues and treatment (McCabe et al., 2021; McDonald et al., 2021; Ragsdale et al., 2024; Wells et al., 2011).

1.5 Summary

Stress is a broad concept that cover both psychological and physiological reactions to environmental demands. Most of the studies in the field are concerned with traumatic stress and/or negative effects of stress during deployment. There is also inter-deployment variability that can vary to such an extent that generalizability is questionable outside of traumatic stressors that seems to be the main source of mental health issues after deployment. Soldiers are not the same what individual factors serves as protective factors vs vulnerabilities (Verrall, 2019).

2 Research aims

I. To study the perception of deployment-related stress, stress-induced change over time in cortisol awakening response, and cognitive performance, on Swedish soldiers deployed in Afghanistan,

II. To study the usefulness of screening using self-evaluation scales to assess stress perception, and mental health, before during and after deployment, to follow "mental health fitness status" during the separate phases, and to investigate potential to predict risk for mental health issues at homecoming.

III. To study the impact of mock scenarios during conduct after capture training on reactive cortisol secretion, and its impact on cognitive function to ensure the aim of the exercise (to create a high intensity stress exposure). The study was based on a request from Försvarsmaktens Överlevnads skola (eng. military survival school), to evaluate the efficacy of the training.

IV. To study how low-level blast (LLB) from breacher training affects cognitive performance, and the release of brain injury markers, after exposure. The study was requested by the special forces to get a valid assessment of potential harm from exposure of LLB.

V. To investigate, based on registry data on American soldiers returning from Afghanistan or Iraq, if age is a factor that impacts recovery after mild Traumatic Brain Injury (mTBI) or Traumatic Brain Injury (TBI) based on results on Neuropsychological testing and self-evaluations scales.

3 Materials and methods

3.1 Ethical permits

All studies that fell under the Ethics Review Act were approved by the ethics review board. Article I: 2013/1213-31/1, article II: 2019-02728, article III: 2019-05361 (ethics review board did not find the study to fall under the ethics review act), article IV: 2015/1036-31/1, article V: IRB approved and registered at https://clinicaltrials.gov/study/NCT01847040

3.2 Study I

3.2.1 Participants

Soldiers from FS 26 deployed to Afghanistan, all male (n = 41) none had previous experience from deployment. The mean age of the participants was 24.9 years (SD 2.2), with an average time of employment at Swedish Armed Forces of 4.5 years.

3.2.2 Measures

PSS14 Perceived Stress Scale (Cohen et al., 1983) is a self-report inventory that consists of 14 items that assess perceived stress during the last month. It is built on two subscales, positive and negative. The items on the positive subscale address stressors that are perceived as manageable, they can actively be managed or coped with, e.g. "I feel in control over the stressors". The negative subscale items relate to stressors that are perceived as hard to manage or difficult to cope with, e.g. "I have no control over the stressors". The score ranges from 0 to 56. Each question is scored using a 5-point scale, where 0 = never and 4 = very often. The psychometric properties of the PSS14 show a high internal consistency (Cronbach's α) ranging from $\alpha = .87$ to $\alpha = .92$. The scale is intended for baseline and follow up measures and lacks norms to compare results with.
d2-R (Brickenkamp et al., 2010) is a test that challenge visual attention. The test is designed to be monotonous and challenging to the ability to keep focus. The difficulty level is the same over the whole test. The test consists of several rows of the letter d in lowercase (see *Figure* 3). The task is to mark some predefined combinations of d and the accompanying marks. There are some legit combinations and some mock combinations. The test is performed with a time limit and is designed to avoid a ceiling effect were one can mark all the correct

stimuli with no error during that time. Accuracy is acquired at the cost of speed and vice versa. The test has several outcome measures, we used tempo and E% (error). The measures are transferred to standardized points with a mean set at 100.

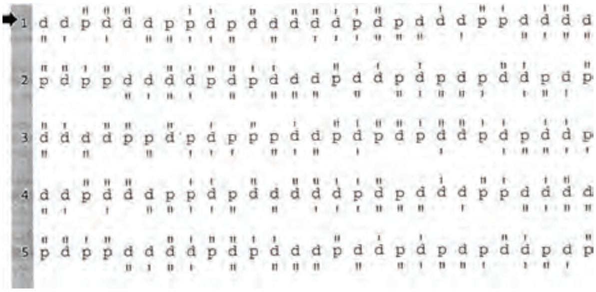

Figure 3. cutout of a d2-R form

Delta-R (Börjesson, 1970) is a test battery addressing IQ. We used only one of the test components, a nonverbal visual leverage test that ranges from simple to complex figures. There is a time limit, and one must be efficient in solving the tasks. Correct items are scored as 1, and the maximum total score is 24 (all correct).

NAB Neuropsychological Assessment Battery (Stern & White, 2004).The Digits forward/Digits backward component of the test, use a well-established test paradigm targeting working memory. The test has two parts, forward and backward. As the name implies the forward is simple number repetition. Then numbers are read in a standardized tempo to the respondent who repeats them in order. Difficulty increases as numbers add up. In the backward part, numbers are read the same way, but the task is to repeat them backwards.

Wordlist memory (WLM) are common used measures of verbal episodic memory (Bock et al., 2021). The lists included 15 randomly selected and unrelated words. The words were read out aloud in a standardized tempo with a neutral tone. The respondent then performed two recalls, the first one direct recall immediately after reading the list, and the second time delayed recall after taking the Delta-R test, the aim is to interrupt memory with a cognitive demanding task that limits the capacity of keeping the words in mind. The respondent was not informed that a delayed recall would take place.

Cortisol was analyzed in study I and III. In study I, the aim was to look at stress impact over time. Prolonged exposure to stress has been shown to influence cortisol as a stress hormone (Clow et al., 2006; Makras et al., 2005). Cortisol is probably the most researched hormone in stress research and it has proven effects on body and brain (Juster & McEwen, 2015; Juster et al., 2010; McEwen, 1998, 2012, 2013; McEwen et al., 2015; McEwen & Sapolsky, 1995; Sapolsky et al., 1986). Cortisol follows a diurnal cycle with the highest levels present after waking up, a phenomenon termed the cortisol awakening response (CAR) (Hellhammer et al., 2009; Wust et al., 2000). Levels related to waking are considered a relatively table measure over time (Matsuda et al., 2012). The levels then decline over the day (Hellhammer et al., 2009; Matsuda et al., 2012). However, stressors encountered over the day will impact reactive cortisol secretion (Bozovic et al., 2013; Hellhammer et al., 2009; Kirschbaum & Hellhammer, 1989; Schlotz et al., 2011). For study I, saliva samples were obtained using Salivette collectors and cotton swabs, samples were then delivered to the Karolinska university laboratory.

3.3 Study II

3.3.1 Participants

This study was based on anonymous forms from the operational psychology evaluations made over the deployment phases during the contingent Mali 05, not all deployed soldiers responded due to operational reasons. A total of 412 forms were collected.

3.3.2 Measures

PSS 14 (see study I). SMBM Shirom Melamed Burnout Measure (Shirom & Melamed, 2006) is a well-known and established questionnaire for assessing underlying factors indicating burnout. 14 items covering three underlying subscales: physical fatigue, cognitive weariness and emotional exhaustion. The items are scored from 1= almost never to 7= almost always. Examples item, of physical fatigue – I feel physically drained, of cognitive weariness – “I feel I’m not focused in my thinking”, and for emotional exhaustion – “I feel I am not capable of being sympathetic to coworkers and customers”. Internal consistency has been shown to be high (Cronbach’s α, 92). There are no set norms for the total score. Clinical experience indicates that an average of 4 indicates a possible need for professional help, and patient that were treated at the Swedish clinical stress center in Stockholm have an average around 5 (Perski, 2013). KSQ Karolinska Sleep Questionnaire (Kecklund, 2018) is a two part questionnaire. The first 18 items cover four dimensions: sleep quality, difficulties waking up, snoring, and sleepiness. A psychometric evaluation and standardization of the test showed a Cronbach's α ranging from 0.71–0.87 over all age groups and dimensions, suggesting good internal reliability (Nordin et al., 2013). The items are scored: from 1 to 6, 1 = always (5 times week or more), 6 = Never. Higher scores equal better sleep. Example items for, Sleep quality, Reoccurring waking up with difficulty going back to sleep, Difficulties waking up, A feeling of not being rested when waking up, Snoring, Apnea during sleep, Sleepiness, Involuntary sleep episodes during work". The second part are seven items in which the respondent makes time estimations on subjects such as time of sleep onset and duration. Only the first part was used in this thesis. Note that in some studies using KSQ the score is reversed so that higher scores equal worse sleep.

3.4 Study III

3.4.1 Participants

Participants undergoing conduct after capture training, spread over three groups A (n = 20), B (n = 23) and C (n = 10), (Mean age 27.6, SD 5.8). All three military branches were represented with a majority from the Air Force (n = 45), Army (n = 7) and one (n = 1) from the Navy.

3.4.2 Measures

A *no name* self-developed digital test was used. The test was made for use on a tablet (Samsung galaxy active tab, with Android Version 4.4.4). The same test paradigm as DANA (see study 4) and ANAM (see study IV) was used för the 3 subtests included SRT, Choise reaction time (CRT) PRT in DANA and GnG. Cortisol (see also Study I) analysis was performed using mobile salivary cortisol assays. The I-calQ is developed for field use (medical), which makes it possible to test the collected saliva onsite with no storage or delays still they were kept frigerated during the exercise before analyzed. It uses the immunoassay test strips *Figure* 4. and image analysis algorithm to analyze the saliva. The cortisol assay utilizes affinity chromatography. That is Antibodies developed with a high affinity for particles of cortisol, these antibodies adhered to cortisol produce a visible signal. The intensity of this signal correlates with the amount of cortisol present in the saliva sample, which is also correlated to the blood concentration of cortisol (I-calQ, LLC; Scottsdale, Arizona, United States).

Figure 4 IcalQ test strips with control and cortisol strip visible

3.5 Study IV

3.5.1 Participants

Operators from special forces (n 14) (Mean age 29 years, SD 3.4).

3.5.2 Measures

3.5.2.1 Cognitive measures

Defense Automated Neurobehavioral Assessment (DANA) version 1.6.5, running on a Samsung galaxy active tab, with Android Version 4.4.4). The DANA software is a digital neuro assessment with 8 subtests (Lathan et al., 2013; Rice et al., 2011). A subtest is simple reaction time (SRT). As describe above, the task is just to react to a given stimuli as fast and accurate as possible. SRT -R is the same test but placed at the end of the battery the test serves as a measurement of stamina, since it addresses the same test paradigm as the first SRT. CODE is a matching task where a symbol and a number are presented together. The presented stimuli are then compared to a code key with nine number/symbol combinations see (*Figure 5)*. The task is to identify if the stimuli combination is correct (according to the code key) or if its false, i.e. the number and symbol are not the same as in the code key. The code key is static within the subtest, so a learning occurs while responding. The code test returns later in the test as CODE R (after PRT, SPAT and GnG). However, this time there is no code key, just the stimuli in form of number and symbol. The added dimension is memory; did any learning occur during the first test? Procedural reaction time (PRT) the test builds on reacting to a stimulus consisting of a number, 2, 3, 4 or 5. If the stimuli is a 2 or 3, then one responds by pressing on the 2-3 button and if it's a 4 or 5 it's the 4-5 button. Mental spatial rotation match (SPAT) displays two bar graph like figures. The second stimuli in the test is rotated in relation to the first figure and the task is to decide if they are alike or not. Go or no go (GnG) is a test that address reaction as well as inhibition. In a grid looking like a brick house there are 6 "windows" where a green or white figure will occur. When it's a white the respondent is supposed to press "fire" and when a green appears the task is to withhold fire. The last subtest before SRT-R is Visual spatial memory (MATCH) a cube with 4x4 tiles in yellow, blue, or white is shown for a brief period. After a short delay two cubes appear side by side, one is identical to the stimuli previously shown and the other a mock stimulus. The task is to recall the pattern on the stimuli.

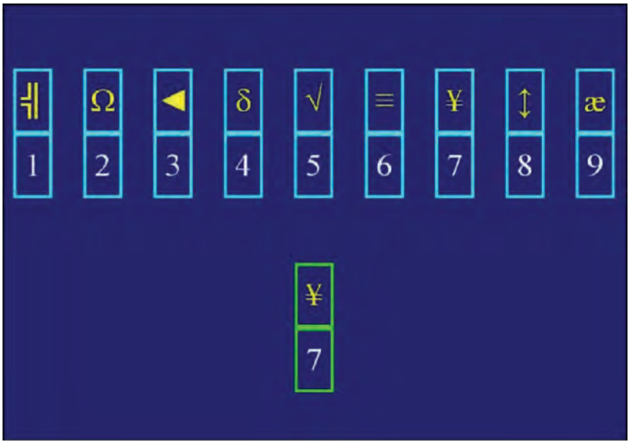

Figure 5. DANA CODE example

Blast exposure was measured using Blast gauge (model H1, software Field application v4.1 BlackBox Biometrics, Inc.), a worn sensor that registers pressure. Each participant wore 3 sensors *Figure 6.* placed on the back of the helmet, on the mid-chest on the worn combat vest, and on the outside (lateral) shoulder.

Figure 6 ("BlackBox Biometrics, the Blast Gauge(R) System, Gen. 7"

3.5.2.2 Biomarkers

Biomarkers for neurotrauma used in this study, were some of the most used markers in brain injury studies. In *Figure 7* the origin of the biomarkers in the neuron are shown. TAU (tubulin associated unit) is a protein that plays a role in stabilizing neuronal microtubules, that are like the cells scaffolding. TBI is a risk factor for tauopathies, repeated exposure to concussions is also related to chronic traumatic encephalopathy (CTE) in athletes and military personnel (Edwards et al., 2020). NFL (neurofilament light) is a protein found in myelinated axons, its levels rise in both cerebrospinal fluid and blood after an injury, proportionally to the degree of damage to the axon. (Gaetani et al., 2019). Tau and NFL concentrations were measured using Single molecule array (Simoa) technology on an HD-1 analyzer (Quanterix, Billerica, MA). S100b is a calcium binding protein found in astrocytic glial cells in the central nervous system. S100b in serum has shown increased levels in relation to brain injury. In severe cases it has been found to correlate with mortality. The S100b protein is larger than what is expected to pass the blood brain barrier (BBB), therefore some argue that it might be more of an indication of BBB integrity. S100b is also present in relation to extracerebral injuries, that can account for increase levels in serum (Goyal et al., 2013).

There are also theories of the glymphatic system, the brains lymphatic system, proposing that the system might transport larger molecules from the brain, thereby increasing serum levels (Mestre et al., 2020). NSE (neuron-specific enolase) is a protein that exists in the neuronal cell bodies and neuroendocrine cells. Levels of NSE in blood has been shown to increase after mTBI and in blast wave-induced brain injury (Wang et al., 2018).NSE and S100B concentrations in blood were measured by immunoassay using cobas e601 with electrochemiluminescence detection (Roche Diagnostics, Penzberg, Germany). The measurements were performed in one round of experiments using one batch of reagents by board-certified laboratory technicians who were blinded to exposure data. Intra-assay coefficients of variation were below 10%.

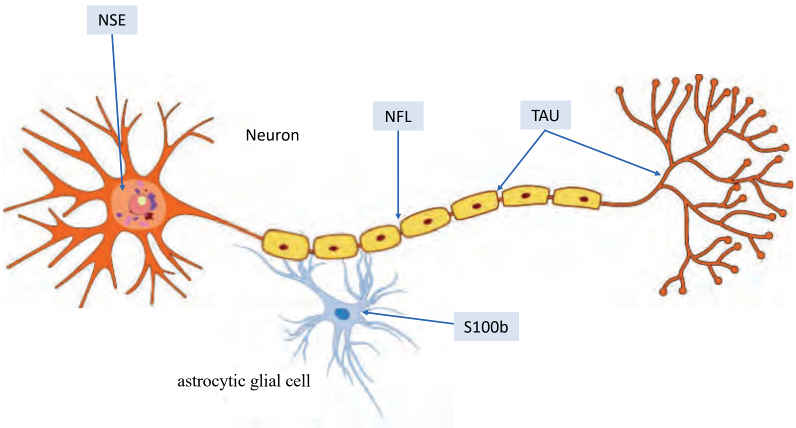

Figure 7. The neuron with approximate sites for the biomarkers

3.6 Study V

3.6.1 Participants

Male US army soldiers (n = 903) (18-40 years) previous deployed in Afghanistan or Iraq, data came from a larger study (The Warrior Strong Study).

3.6.2 Measures

Automated Neuropsychological Assessment Metrics version 4, military TBI (ANAM4 TBI-Mil) is a computerized test that can be tailored to the needs of the assessment (subtests and questionnaires)(Iverson et al., 2019; Rice et al., 2011; Roebuck-Spencer et al., 2007). The battery used for the participants in our study included 7 subtests. ANAM TBI-Mil is built on the same test protocol as DANA with subtests such as SRT (SR2 for the repeated test in the end), Code substitution learning CDS (CODE in DANA), and Code Substitution Delayed CDD (CODE-R in DANA), Procedural reaction time PRO (PRT in DANA). Matching to sample M2S (MaTCH in DANA). Subtest that are not in DANA is, Mathematical Processing Measures MTH solving simple arithmetic problems and provide a reply on whether it is less than or greater than 5. NSI Neurobehavioral Symptom Inventory (Silva, 2021). The NSI assess 22 cognitive, affective, sensory, somatic, and vestibular symptoms using a 5-point Likert-type scale. NSI data can be evaluated in many ways: individual symptoms, symptom domains, using an overall score, as well as using the overall number of symptoms, number of them at specific severity levels, and the number of symptoms from specific domains. Symptoms associated with the frontal lobe function were defined as poor concentration, forgetfulness, difficulty making decisions, slowed thinking, fatigue, sleep problems, feeling anxious, depressed, irritable, poor frustration tolerance, sensitivity to noise, numbness, and appetite change.

3.7 Statistics

Main statistics for all studies SPSS (IBM Corp.; released in 2017; IBM SPSS Statistics for Mac; Version 25.0; Armonk, NY: IBM Corp). Graphs were made using, GraphPad Prism version 10.0.0 for Mac OS X, and Wizard pro Version 1.9.49. Significant level was set at ($p < .05$). Microsoft Corporation. (2018). Microsoft Excel. RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA, Used by Statistician from LIME (Department of Learning, Informatics, Management and Ethics at Karolinska Institute).

In study I, one-way repeated measures ANOVA was used to compare the PSS14 scores from the test events prior to, during and after deployment. Paired t-tests were used post hoc, with a repeated measures design. Effect size was calculated using Cohen's d.

In study II, an ANOVA was used for individual scores over time. Post hoc testing was done with Tukey HSD (honestly significant difference). Correlations among tests over time was done using Pearson correlation coefficient calculations in Excel.

In study III, Cognitive measures were analyzed using a MANOVA repeated-measure design covering between-group and within- group baseline-post-measurements, comparisons. The use of a MANOVA was motivated by the assumption that all cognitive subtests measure an underlying function that could indicate an overall effect. Cortisol measures were compared based on group means and complemented with analysis of AUC area under the curve. In study

IV, ANOVA was used for blast gauge data and repeated measures ANOVA, for biomarkers post-hoc tests were pairwise comparison using Bonferroni correction. Effect sizes were calculated using Cohens *d*.

In study V, General linear models (GLM) were used to compare mean throughput percentiles for each ANAM test, GDS, and OTBM percentiles. A Bonferroni correction was used to set the significance criterion for all pairwise comparisons in the GLMs at 0.01 to account for the effects of multiple comparisons.

4 Results

4.1 Study I

Self-rated stress measured using the Perceived Stress Scale (PSS14), showed that the total stress scores dropped during deployment compared to the values obtained before and at homecoming see (Table 1). The overall mean changes were significant. Post hoc tests showed that the significant differences were obtained between the pre deployment to the during deployment measurements, and the during deployment to homecoming assessments. The PSS14 is built on two subscales, positive (controllable) and negative (uncontrollable) stress. The negative subscale accounted for most of the drop for the during assessment compared to the values obtained at pre and homecoming. Cognitive tests, Delta-R, NAB, Word list, and d2E% (error), did not differ between tests taken before deployment and at homecoming. However, d2 Tempo increased significantly at homecoming (norm-referenced scores), indicating a higher processing speed. Mean cortisol awakening response levels went from 31.15 nmol/l before deployment, to 26.59 nmol/l at homecoming. This difference represents a significant decline.

4.2 Study II

PSS14 mean scores showed significant differences over the three time points pre deployment, during deployment and at homecoming. Post hoc test showed that the main difference was between the mid time point (during deployment) and at homecoming. Congruent with study I, the negative subscale of PSS14 accounted for the difference, with a non-significant drop from before to during - deployment, and a significant increase from during deployment to homecoming. A comparison between the PSS14 results from study I and II are shown in *Table 1*.

Measure	Pre deployment		During deployment		Homecoming	
	M	***SD***	***M***	***SD***	***M***	***SD***
PSS14 sum Study I	23.93	7.87	20.26	7.31	21.82	8.16
PSS14 sum Study II	18.57	7.68	16,65	6.97	19,89	7.18
Negative subscale Study I	13.73	5.02	10.39	4.41	11.37	4.84
Negative subscale Study II	10.45	4.28	9.21	*4.27*	11.84	4.16

Table 1. Comparison of means for PSS14 from study I and II. All changes over time were significant at the .005 level.

Sleep statistics assessed using the Karolinska Sleep Questionnaire (KSQ) showed no change over time on any of the subscales or the total sum scale. Shirom Melamed Burnout Measure (SMBM) showed an increase between the assessments made during deployment and at homecoming. Only a few had a mean score over 4 (an item is considered on a clinical level when scored 4 or above). *Table 2.* shows the distribution of mean scores over the assessment times. Noteworthy is that the clinical reference value 4, is not based on norms but on recommendations from one of the leading treatment centers of burnout in Sweden. It does not relate to a total mean score but to individual items. An individual can have multiple items with a score of 4 or above, but still have a mean below, making the mean that we used here a conservative measure.

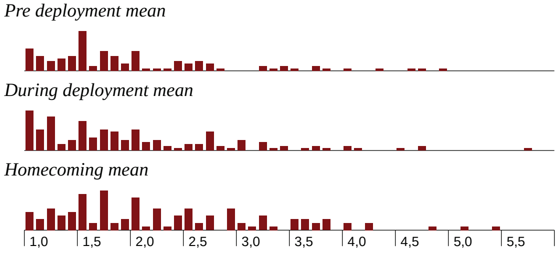

Table 2. Distribution of SMBM mean scores on the x-axis, the bars represent individuals with that mean score.

The potential to predict mental health risk over deployment phases turned out to be low hence the usefulness in that sense can be questioned. There were some moderate correlations between the negative subscale of PSS14 pre deployment, and the KSQ and the SMBM during deployment. Correlations were found mainly within the same test event (time point). There were basically no correlations between the two first test events and the measurements performed at homecoming.

4.3 Study III

The two dependent variables were cognitive tests and cortisol. A MANOVA with a repeated-measures design, showed that the reaction times did not differ between the two, time points baseline and follow up, or between the three studied groups. The reaction times differed for the three different test components due to their complexity, Simple Reaction Time (SRT) as the name implies, has the shortest processing and reacting time. Choice Reaction Time (CRT) had more than double processing time compared to the SRT. For the third test Go no Go (GnG) the tested dimensions are inhibition as well as reaction time and as visualized in *Figure 8*, The processing time for that is slightly higher than for SRT.

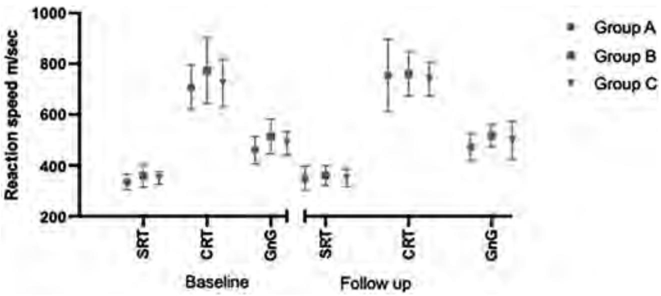

Figure 8. Cognitive test for all groups A-C at baseline and follow-up; the vertical bars represent on standard deviation. SRT= simple reaction time; CRT, choice reaction time; GnG go or no go.

Cortisol levels from the baseline measure including cortisol awakening response (CAR), and an evening measure, gives us an estimated slope of the daily decline of cortisol levels. During the training the cortisol samples showed different patterns, with elevated levels over the course of the day, shown in *Figure 9*.

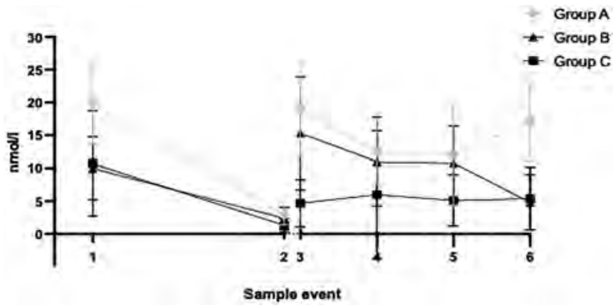

Figure 9. All groups over all events: 1-2 baseline, 3-6 during CAC (vertical bars one SD)

Cortisol measures were also calculated as area under the curve (AUC) to compare the change of the area during the exercise compared to baseline. The AUC was significantly higher during the training than at baseline. The first measure for group C, during CAC, did however, differ in a way that might indicate an artefact. An ANOVA for the AUC over time and between groups, showed significant results for all effects (Group, Time, Group:Time). Subsequent pairwise comparison within the groups showed that group A and B differed significantly, while group C did not (possible, due to artefact in measure).

Comment: Cortisol levels for group C at baseline differed so much from the expected level that there is reason to suspect some kind of artefact. The same procedure was used in all cases. A possible explanation lies in the analytic software the version or setting of IcalQ at that time.

4.4 Study IV

The blast gauges worn to register pressures from the breaching training provided these results (mean over all participants), head (back of helmet) at kPa 12.20 SD

3.65 (1.77 psi SD 0.53), shoulder kPa 15.17 SD 6.2 (2,2 psi SD 0.9), and Chest kPa 20.41 SD 9.0 (2.96 psi SD 1.31). This indicated that the main blast was taken on the chest. An ANOVA showed a significant difference over the mounts.

The biomarkers for neurotrauma were all elevated after the training events but returned to baseline levels after 3-5 days as shown in *Figure 10*, using repeated measures ANOVA for each biomarker, the change over time were significant for all markers. Post Hoc test showed significant difference for the individual biomarkers as follows, TAU between time 1-2, and 2-4. For S100b between 1 and 2-4 (all subsequent events). For NFL between 2-3 and 2-4. And for NSE 1-3 and 1-4.

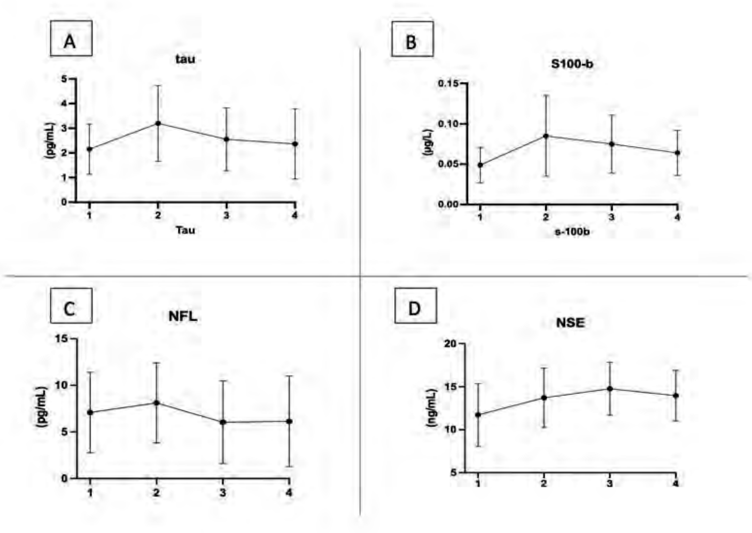

Figure 10. Biomarkers over the test events baseline 1. 2.-3. during training and 4. 3-5 days after

The results from the cognitive tests did differ between the two test events. Five (SRT, CODE, PRT, SPAT, CODE-R) of eight subtests resulted in significantly lower reaction times at follow-up compared to baseline. Noteworthy is that effects sizes of the differences, ranged from .64 to 1.52 that indicates medium to large effect size (T*able 3).*

Paired Samples T-Test

Sub test	t	df	p	Cohen's d
SRT	2.220	11	.048*	0.641
CODE	3.017	11	.012*	0.871
PRT	3.305	11	.007*	0.954
SPAT	5.247	11	< .001*	1.515
G N G	1.275	11	0.229	0.368
CODE R	2.850	11	0.016*	0.823
MATCH	1.642	11	0.129	0.474
SRT -R	0.413	11	0.687	0.119

*Table 1 Test Data summary: pre and post mean response times for DANA subtests * = p < .05*

4.5 Study V

ANAM TBI-MIL showed a significantly lower "throughput" (a composite measure derived from accuracy and speed), for the 28–40-year-old group (with TBI), in 4 (SRT, CDS, MTH and SR2) of the 7 subtests. In the 25-27 (with TBI) group only one subtest (SRT) differed (lower) significantly. Between the TBI and, no TBI for the youngest group < 24 there was no significant difference. The General Deficit Score (GDS) was significantly higher for the 28-40 group with TBI compared to the < 24 with no TBI see *Figure 11*.

The overall test battery mean, OTBM were significantly lower for the 28-40-year-old group +TBI, compared to all other groups with or without TBI.

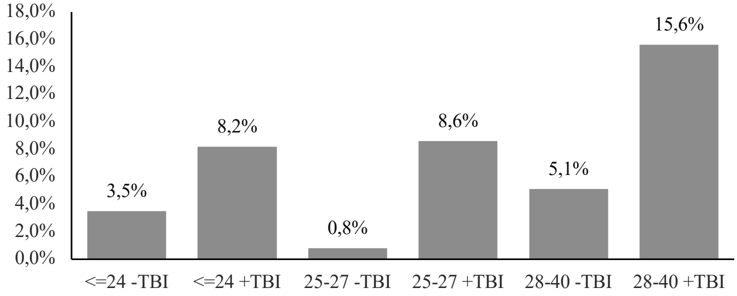

Figure 11. Base rates of ANAM performance deficits (GDS>=1.0) by age and post-deployment TBI screening results, -TBI equal no TBI and +TBI indicates TBI.

Aside from cognitive measures, the Neurobehavioral Symptom Inventory NSI was given to the participants. The results showed a significant difference for most of the symptoms (22 items + HAD) from the reference group (soldiers < 24 with no TBI) see *Figure 12*.

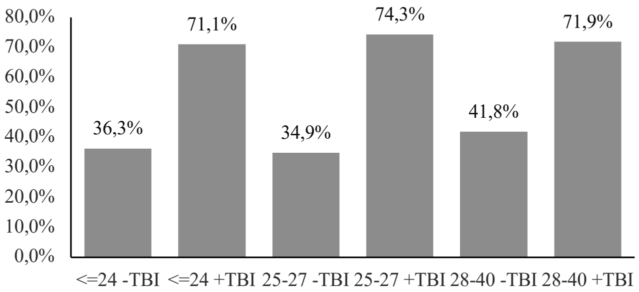

Figure 12. Base rates of moderate to very severe frontal lobe-related symptoms by age and post-deployment TBI screening results -TBI equal no TBI and +TBI indicates TBI.

ANAM TBI-MIL showed a significantly lower "throughput" (a composite measure derived from accuracy and speed), for the 28–40-year-old group (with TBI), in 4 of the 7 subtests. In the 25-27 (with TBI) group only one subtest differed (lower) significantly. Between the TBI and, no TBI for the youngest group <= 24 there was no significant difference. The General Deficit Score (GDS) was significantly higher for the 28-40 group with TBI compared to the <= 24 with no TBI.

5 Discussion

The primary objective of this thesis is to analyze the nuanced dynamics of military stress, particularly focusing on the cognitive and physiological impacts on soldiers in both deployment and training settings. The guiding study questions are: How do various stressors in military environments affect cognitive performance and stress related health, an answer that hopefully could help us mitigate adverse effects while maximizing the operational readiness and psychological resilience of military personnel.

The existing military psychology literature is often directed towards psychological trauma. Hence the general view of military deployment as inevitable source of negative stress can and must be challenged. Saying that military missions is not necessarily stressing in a harmful way must not be confused with that it's not a challenging task. There is still a substantial risk associated with the deployments. Even when the risk is realized, that is when troops are exposed to and participating in combat, it's not inevitably a negative outcome. Risk and hardship can foster comradery and a sense of meaningfulness. The fact that deployment can have effects that is rewarding for the individual should not cast a shadow on the well-deserved pride and honour that the Veterans should have after deployment.

In the Swedish military doctrine, the mental state of the staff is considered an operative resource. The Swedish military doctrine is built on three pillars. *Figure 13*. Physical, conceptual, and moral factors. Moral factors are a multifaceted concept that builds on wellbeing, loyalty, mental health, mindset etc.

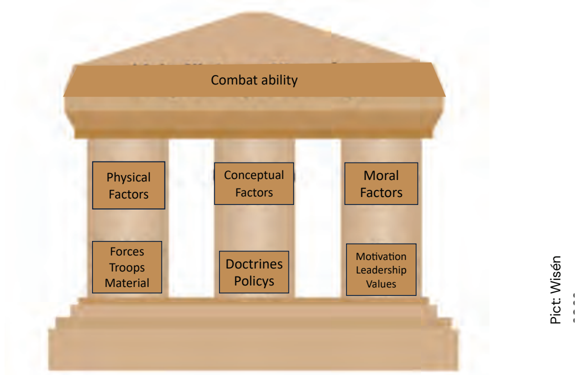

Figure 13. Swedish Combat ability model

We also want to direct the focus on the fact that military peacekeeping operations are not inevitably filled with negative stressors. They can be rewarding and provide the soldier with a positive and growth-related experience.

We need to be relevant in how we support our soldiers and subsequently our veterans(Shigemura et al., 2016). We do that best when we build on knowledge-based research. When it comes to health specifically, we are concerned with exposure that can have a negative effect on both mental and physical health. Our Aim here is to combine cognitive aspects of health and biomarkers of stress and brain injury, to identify risk scenarios in training or deployment hazards that needs to be addressed and managed. We also want to explore the usefulness and relevance of a more operative approach to psychological research in the armed forces. That is performing studies in everyday activities and in the operational environment.

In Study I the results show that perceived stress decreased during the deployment. A result that is in line with experience from following up Swedish veterans during the last 1,5 decades. During that time there have been some substantial shifts in deployment related factors. First of all, the recruitment has shifted from being temporary contingents manned with civilians who were recruited just for that mission (previous basic military education required). Since around 2009 the main part of contingents has been set up by a selected regiment using mostly contracted soldiers. A change that has implications not just on team cohesion, but also after deployment where follow up don't have to be limited to a homecoming processing over a few days. There has also been a change in the laws that regulate the responsibility to follow up. The Swedish armed forces now have a program that is guided by the actual exposure of stress in various forms during deployment.

In Study I our participants expected a higher risk environment before they went on deployment, than what they experience on site. As it turned out, they did not experience any combat related stressors, however that is not the same as an absence of risk. Risk is always present in deployment areas, and if managed correctly it will not be perceived as a stressor. In this case we can argue that risk was not a prominent stressor. We measured stress perception but not the factors behind them. Negative stress i.e. the stress that comes from lack of control is the type of stressor that accounts for the decline in the overall stress score. An explanation that is plausible is that during deployment the role of the soldier and the tasks/assignments are well defined and limited, leading to a feeling of control.

Most modern military research in the field of mental health and deployment, is carried out on troops deployed in conflicts with asymmetric threats (insurgents, IEDs, non-uniformed enemies etc.). Since the war in Ukraine broke out focus has shifted towards other aspects of mental health in combat. Recent studies based on Ukraine soldiers, calls for well-grounded preparation programs and models to work with military personnel and mental health (Haydabrus et al., 2022; Kokun et al., 2023; Prykhodko, 2022). One could argue that there is time to shift from a peacekeeping/deployment mental health paradigm to a defence mental health paradigm, with focus not just on mental health but also on sustainability, and resilience as part of one of the three pillars of "krigsföringsförmåga" (Försvarsmakten, 2022).

The results from Study I and Study II both show that stress in the form of any kind of mental load on the soldier, varies over the deployment phases. The daily life during deployment contains both hassles and uplifts. When there is a positive balance in favour of uplifts or other protective factors the "sum" can mitigate the adverse effects of hassles (DeLongis et al., 1982; Heron et al., 2013; Kanner et al., 1981; Larsson et al., 2016; Larsson, 2017; Raju, 2014). Since stress was lower during deployment than before or after, in Study I, the sub-hypothesis that we would see cortisol levels increase and cognitive performance decline as a reaction to prolonged stress, was disapproved. Relying on a "sense" of how staff is doing regarding stress is not sufficient, we therefore tested ways to assess the whole contingent. In Study II we studied if screening methods could be used to assess "mental health fitness" of troops and if the results would provide valuable information in preparation of homecoming. Even though there were missing data (drop-outs) due to operational demands, we still obtained enough data to provide the command with data concerning psychological status during deployment. However, the results did not support the hypothesis of a predictive value of the screenings, at least not in a direct way.

The scores of the self-evaluations on PSS14 in study II, follow the same pattern as in Study I thus being lower during the mid-phase than before or after. If we compare the PSS14 mean for all timepoints between study I and II, the PSS14 results were lower at all timepoints during Study II. There is no obvious reason for that difference in scores between the two studies. Plausible explanations could be regiment culture, expected and communicated risk in deployment area, and group characteristics. In the first study the study group consists of guard and escort soldiers, with no previous experience and a mean age in the mid 20s (*M*=24,9 *SD*=2.2). In Study II all personnel was given the assessment form, all positions were included: support functions, staff positions, administrative personnel, UAV operators and soldiers in "field" duty. We lack descriptive demographics to compare age groups, but a substantial part of the contingent were over 30 years old. It is possible that age, experience, and position have a mitigating effect on perceived stress rendering it lower for all time points.

The contingent in Mali was exposed to numerous attacks on the camp relatively close to homecoming. The screening of the contingent during deployment was performed before the attacks. The homecoming screening might capture some effects from the attacks, but as an direct evaluation after an attack, a reactive screening should be performed on site. Working as an operational psychologist with that contingent the clinical observation of the troops on a group level indicated a heightened anxiety or vigilance, an observation that is not supported in the results from the screening. That raises the question if appropriate scales for screening were selected. We looked at stress, sleep and burnout, all relevant measures which could have been supplemented with a vigilance scale based on the attacks. However, the burnout measure SMBM, which is a well-established measure in research and in clinical use showed a small but significant increase of the mean score on group level. There were also seven individuals with a mean of 4 and above, there is no given "cut off" but that score, according to "stress mottagningen" in Stockholm indicates a clinical level of burnout symptoms (Lundgren-Nilsson et al., 2012). The presence of several individuals with a score of four or above is an observandum, since it indicates a lack of work recovery balance during deployment. That shows the importance of addressing organizational factors such as leadership and culture (Bono et al., 2013; Fors Brandebo, 2020).

There are substantial recourses spent on follow-up programs, veteran mental health support etc. Simply assessing stress at several times over the deployment phases will not changes the need for following-up programs when it comes to stress exposure. We need to take the guesswork out of troop assessment and apply psychological measures not just to identify those in need, but to be proactive and adapt to sudden changes in combat fitness. Since one of the main contributors to mental health issues is combat or intense protentional traumatizing stress, some stressors might be acted on by the leadership i.e. mitigated once identified. Other stressors need to be managed directly by the individual him/herself. In Study III we looked closer at a training scenario aimed at just that, managing intense stressors to maintain function (McEwen, 2016). The general aim, to create a high intensity stress exposure, was met, Cortisol levels e.g., were highly elevated during the exercise (except for one group). When controlled for some of the confounding aspects of each participating group, we found some interesting aspects that warrants further studies with CAC training.

We found in accordance with previous research on sleep and fatigue and stress, that the group that was sleep deprived and fatigued appeared more susceptible to the stress exposure (Dolezal et al., 2017; McEwen & Karatsoreos, 2015; Medic et al., 2017; Suurd Ralph et al., 2017). Therefore, pre-exhaustion of participants might be a way to amplify the intended stress effect on participants with less intense stress stimuli. There is, however, a risk of less learning when sleep deprived (Pierard et al., 2004). We had the opportunity to perform the study on three groups, and for the second and third group we controlled sleep and nutrition i.e. they were well rested and feed before capture. As it appeared the second group was slightly different as they were going through the same exercise but in the context of an instructor course and not in a SERE course, as the two other groups was. The main difference was that the second group had a longer pre-CAC period within the instructor course, so they got to know each other. The participants in the instructor course also had previous similar experience from SERE training. Taken together we had possible confounders in group cohesion as a protective factor against stress (Brooks & Greenberg, 2018; Campbell-Sills et al., 2022; Franz et al., 2013; Jones et al., 2012), in rest and nutritional state and previous experience.

How much these factors contribute as stress mitigating or coping factors, is a question for further studies. Based on the results and in relation to previous research we can sort those confounders under protective factors. However, in a training scenario where we want participants to be stressed, initially even beyond their functional coping capacity, the identified factors can be used to lower the amount of aversive stress needed to achieve the desired effect. Performing the CAC scenario early in the SERE course before group processes has taken place, interrupt sleep previous days, and make them miss a meal or two, will render the participants more vulnerable for the mock stressors.

The results from the cognitive tests given before and directly after the exercise did not differ. Cognitive function was also indirectly assessed ´during the exercise. Participants were exposed to several plojs, each ploj targets some of the models and strategies taught the preceding week. Participants were often overwhelmed with the situational stress, and lost contact with cognitive resources and functional ways to make use of the strategies. When so the instructors (in their role as hostile captors) would decrease the intensity and provide some subtle hints until the participant succeeds with the ploj. That mental freeze indicates a temporary cognitive impairment. Observation between plojs and the results from the "after" cognitive testing indicates that the kind of decline in cognitive function requires only little recovery to regain function. The results might hold several potential applications outside of the CAC training scenario.

In Study IV, LLB exposure during breaching, we studied two courses going through the breacher training week. A week that contains several training components, breaching being one of them. Compared to other breaching studies (Carr et al., 2016; Tate et al., 2013) that covered a more intense LLB exposure during the training, our participants were much less exposed. Since Study III was requested by the special forces, to investigate if LLB exposure in training is a risk factor for the operators we did not want to alter the training protocol. Even though they were exposed to a limited amount of LLB they showed a statistically significant reaction in biomarkers for neurotrauma. We compared baseline levels for both biomarkers and cognitive performance with after measures, and found a reactive response, however it did not correlate with a decline of cognitive performance. Tate et al. found that breachers who had the highest reactivity in biomarkers also had the most prominent change in cognitive performance (decline)(Tate et al., 2013), that is an observation that could be useful in determining potentially harmful effect from blast exposure, it is not always possible to run a full set of biomarkers, but assessing cognitive function is easily done, but it requires individual baseline measures in order to get a valid evaluation of potential functional decline. As shown in Study V baseline measures provide relevant reference data in the occurrence of TBI or mTBI. A fact that gets support from other studies in the field (Baker et al., 2011). However not all the participants had baseline measures. If we have had baseline measures, we could have looked at decline in cognitive performance comparing it to the post measures, not just the throughput. Now we were limited to compare the outcome measures for TBI or no TBI over the age groups. The results are obvious in that performance for most of the subtests are significantly lower in the age group from 28 to 40 is significantly lower in performance for most of the subtest. When looking at the Global Deficit (or Deterioration) Score (Reisberg et al., 1982), we found that the 28-40 group have more individuals who score higher (worse) than the younger groups in correlation with the ANAM scores. We do, however not know about the severity of the injury, a fact that cold have been of interest. Now we can just assume that injury severity is randomly distributed over the whole sample. We also know that the 28-40 group have a higher number of lifetimes TBI's 2.70 compared to 1.8 (age <24) and 1.97 (age 25-27). We cannot say how much the repetitive exposure accounts for though. Referring to the sport arena where concussion has been a relevant topic for years, we do find indirect support for the hypothesis that repeated concussions pose an increased risk (Farnsworth et al., 2017; Shahim et al., 2014). All in all it's a complex filed with multiple factors or as Vartanian and colleges argues "that the broader injury context must, therefore be considered when studying the impact of repetitive low-level explosives on heath and performance in military members" (Vartanian et al., 2020).

The use of digital test for cognitive performance is a simple and cost efficient. Test like DANA or ANAM are easy to administer and to follow up not just performance but also long-term effects from training, and after deployment, the standardised screenings procedures used could easily be incorporated in the digital platform making data available for analysis to optimise troop performance overall. As shown in study V, it was the extensive use of ANAM that provided the data. Data and results that can affect how we diagnose, treat and follow up TBI. In the planning stage of study one we included wrist worn sleep monitors, unfortunately the promised battery time was only theoretical, so the monitors stopped registering data just a couple of weeks in the mission, leaving us with only partial fragmented data, so that part was binned. However, sleep is a relevant marker. Sleep has a relevant role in all the studies in this thesis, Sleep impact cortisol production (Juster & McEwen, 2015; Juster et al., 2010) and should be controlled for in subsequent studies. Sleep has also the potential to affect the glymphatic system (Chong et al., 2022; Jessen et al., 2015). Changes that also could impact the use and validity of biomarkers after LLB as an example (where levels might be significantly affected but the clinical validity might be questionable). The method in this thesis is not just about data collection. As mentioned, one aim is to promote more operational and field-oriented research. Methods must be easy to use with little or no disturbance on the task at hand. In the CAC study we used a device for filed analysis of biomarkers such as cortisol. the field technology developed for detection of congenital hypothyroidism, now includes a variety of biomarkers cortisol being one. A device developed for eliminating traditional lab work and bringing the analysis to the filed proved to be a valid method to use in a military setting. The emergence of bio monitors such as smartwatches, smart “rings” that collect data 24/7 can be the next relevant measures that can be collected over time. What will the next relevant measure be? Heart rate Variability, Insulin/blood sugar, movement, we must continue to be curious and use new technology to the fullest. Still in some circumstances the old pen-and-paper versions is hard to beat.

6 Conclusions

This thesis challenges the prevailing view of military deployments as uniformly stressful, revealing a more complex reality where deployments can often reduce perceived stress and foster personal growth. Deployments differ both between and within them. The findings underscore the importance of structured psychological assessments for maintaining soldier wellbeing and readiness in relation to the variability of deployment stress. It also highlights the need for continuous research and adaptive strategies in military psychology.

Study I: Our results show that perceived stress was lower during deployment than before and after deployment. This finding calls for a change in focus from negative stress towards possible positive aspects or growth mindset of deployment. It brings us to the question if we can identify and learn from protective factors in ways that lets us reproduce them where they don't appear naturally or are being supressed by hassles.

Study 2: We concluded that structurally assessing the troops is a valid way to assess troops in a potentially high-stress environment providing us with a current status or fitness value of the troops. The next step is to use digital platforms instead of paper and pen, minimizing time spent analysing data. Cumulative stress and stress coming from non-combat stressors can be assessed during deployment and if identified, mitigated before wear and tear sets in.

Study III: What we observed was that the soldiers that were sleep- and food-deprived had the highest levels of cortisol reaction, indicating a higher stress response. Therefore, pre-exhaustion of participants might be a way to amplify the intended stress effect on participants with less intense stress stimuli. There is, however, a risk of less learning when sleep deprived (Pierard et al., 2004). Are there individual factors that makes the individual more resilient or susceptible to CAC stressors? This question warrants further research and could be helpful in the further development of CAC training. Studies such as this one are relevant in that we must evaluate and validate training paradigms to develop them further.

Study IV: Blast exposure is not just occurring in breacher training. This brings forth the relevance of Baseline measures with cognitive test. Without individual baselines we cannot identify decline in cognitive performance if the decline is above the normative value. As argued the accessibility and low cost and noninvasive nature of neuropsychological tests, should open up for mass testing before deployment and or other scenarios where blast exposure might be a natural part of training, combat or in accidental conditions.

Study V: showed age related differences. The older 28–40-year group, with TBI had lower reaction times (worse) than the younger age groups. This could be dependent on several factors such as TBI history, PTSD, or other underlying individual factors. Since age groups is not just arbitrary assigned but based on brain maturation, there might be some aspects here that holds protective aspects of the younger brain. Could it be something that can identified and used in treatment or rehabilitative strategies. As with study IV it also shows the importance for not just baseline measures, but some continuity in following up brain function. Its noninvasive a cost efficient and could be a way to find early warning signs for staff that are repeatedly exposed.

7 Points of perspective

Deployment psychology both related to performance, sustainability, and health, is a well-researched topic. There have been multiple views on war and how it affects man, in the history of mankind. It ranges from “vice” that is a tendency to react negatively with what we today would consider acute- or post-traumatic stress responses. Regardless of how we label or view mental health issues related to PTE, it is still an issue that we have no given solution to. We often present it as normal reactions to an abnormal situation, but when those reactions become maladaptive, we have a problem. Even though one can see a connection between exposure and the prevalence and magnitude of stress reactions and ill health, there is no causal relation, most individuals manage to cope or recover functionally from even the most adverse situations.

What we need to explore further is how to select, prepare, manage, and follow up our personnel. We need to further look at both protective factors and risks for negative load, on both individual and group level. It is obvious that we need to broaden our perspective to be more of a holistic approach. With holistic I mean an approach where we look at the soldier role as a part in a system. A system that is not limited to the military environment and the direct professional aspects of one’s position. We need to look at the soldier in the context of the military, his/her social environment, nutrition, fitness, economics, existential etc.

Its fairy obvious that military psychology is an area that overlaps several other disciplines such as MORALE (one of the three pillars of Combat ability). We need to work in collaboration with chaplains, personnel, and of cause military officers in multi professional teams. There is a fallacy to believe that this is an area exclusive for psychologists or researchers only. In several conferences that I have attended it's obvious that there is a gap between the target group e.g. the military and the military researchers. We need not just to mind that gap but to close it as much as possible. One way is to answer relevant questions that spawn from the core capacities. Both the CAC study and the Breaching study was driven by a need for knowledge from the units themselves. That is also why we performed the research with as little interference as possible to the regular training. One nonbeneficial side effect is that we lose some control over confounders, and the possibility to regulate and standardize the exposure that we are researching.

To summarize these two paragraphs, I propose that further research should take on a more field like approach. It's not just train as you fight, fight as you train. It's also research as you fight/train. Operative research can be a part of contingents and take on both qualitative and quantitative forms. For the record I'm not suggesting that all research should be in the field, but that it should be more of that, and the development and mobility of both cognitive, biomarkers and other tests opens up for more of that.

TBI and mTBI are closely related to PTSD, our aim in study V was to investigate if age at onset is a factor that is relevant for how we tailor treatment. Being able to differentiate between PTSD and TBI/mTBI is another challenging task. Some propose the use of biomarkers in diagnosing PTSD (Liu et al., 2013). One thought that arise is, do PTSD and mTBI effect the results in neuropsychological test the same way or do they show different profiles? If so could they be used to tailor made interventions?

The other thing I would like to feedforward is the relevance of cultural and situational adaption of military research. No deployment is the other one alike, what are the most relevant components that has impact on morale and mental health and performance?

Future studies should set the ground for a more standardized way to categorize deployments not just based on combat exposure, but from a variety of stressors. In the Swedish military we have a model for "contingent evaluation" with focus on the impact on personnel. The model is based on the form of many well-established risk evaluation models used in forensic psychiatry, and with norm breaking youth. It could be developed further and not with just peacekeeping missions in focus. Especially since modern day warfare has shown itself to not be so modern after all.

The bulk of the literature is from western military research, it's based on asymmetric warfare and not the traditional troop against troop, that we now whiteness in Ukraine. That has been the case in Sweden during the last decades when we have had our focus on being a part of international operations to build world peace rather than as we used to, prioritize the invasion defense. Cultures differ among nations and since this is a thesis based on Swedish military the Swedish context/culture is relevant for further domestic research. That calls for a new approach. Previous studies have been mostly directed towards the veteran community and their experience and health after deployment. Although registry studies and veteran oriented studies has provided us with relevant knowledge, we also need studies that will have a more direct impact on both strategic, tactical, and operational levels.

8 Acknowledgements

There are several people that have been of great importance and value during this process.

First and foremost, I'd like to thank Lena Sköld, at the time when I started this thesis, she was the commander of the Swedish Defense Human Resource center. She was the one who made it all possible by giving me time and recourses to start my academic journey. Thank you, Lena, without that support none of this would have happened.

I also want to bring forward my supervisor, Mårten who I know since mid 90´s when I first worked at Karolinska Institutet in a totally different role. When it was time to look for a base for my research, Mårtens unit Experimental Traumatology XT was a natural place to go since they are aimed at military research and I felt I already knew them. At XT we also find my Head supervisor Ulf Arborelius who I especially want to thank for not giving up on me when I have lost track and ran away in other directions (happened a lot).

When I started, I had two supervisors at the stress research institute, Giorgio Grossi and Göran Kecklund. After some time, Giorgio Decided to leave the university for clinical work and Göran got a new position elsewhere hence the change of supervisors.

When they left, I got one of the most known professors in the area of military psychology and leadership, Gerry Larsson. He have been a great help when it comes to the most challenging part of my way towards the disputation, writing! I have had the opportunities to go to Karlstad at the department of leadership a branch of the Swedish Defense University. Those writing sessions made huge progress for me.

Since I have done this work over a long time and under different arrangement, It has also been something that I have focused on in my spare time. For that I would like to thank my wife Malin who has put up with me being emerged in writing from time to time.

There are of cause other individuals that have been important parts in this quest. Family and friends, colleagues, and international collaborators. No one named, no one forgotten. You all know who you are.

I would also like to thank the Swedish armed forces, and the soldiers that participated in my studies. Some of them during my own deployment in Mali 05

- This is for you my brothers in arms.

9 References

Álvares, R. S. R., Mendonça-de-Souza, A. C. F., Duarte, A. F. A., Gameiro, T. M., Fischer, N. L., Souza, W. F., Coutinho, E., Figueira, I., Volchan, E., & Souza, G. G. L. (2020). Exposure to stressful events during a peacekeeping mission may have a price: The impact on trait of negative and positive affect and mental health. *Journal of health psychology*, *25*(9), 1285-1291. https://doi.org/10.1177/1359105317753715

Armstrong, N. C., Smith, S. J. R., Risius, D., Doyle, D., Wardle, S. L., Greeves, J. P., House, J. R., Tipton, M., & Lomax, M. (2023). Cognitive performance of military men and women during prolonged load carriage. *BMJ Military Health 169*(1), 37-45. https://doi.org/10.1136/bmjmilitary-2021-002000

Aux-Analysis. (2017). *Uppföljning av svenska militära utlandsveteraner efter hemkomst från internationell insats, Årsrapport 2017 Psykisk Ohälsa*.

Aux-Analysis. (2018). *Uppföljning av svenska militära utlandsveteraner efter hemkomst från internationell insats. Årsrapport 2018 Fysisk Ohälsa*.

Baker, A. J., Topolovec-Vranic, J., Michalak, A., Pollmann-Mudryj, M.-A., Ouchterlony, D., Cheung, B., & Tien, H. C. (2011). Controlled Blast Exposure During Forced Explosive Entry Training and Mild Traumatic Brain Injury. *The Journal of Trauma 71*(5 Suppl 1, Canadian Forces Operational Medicine Supplement), S472-S477. https://doi.org/10.1097/TA.0b013e318232e7da

Bartone, P. T., Adler, A. B., & Vaitkus, M. A. (1998). Dimensions of psychological stress in peacekeeping operations. *Journal of Military Medicine 163*(9), 587-593.

Bates, M. J., Fallesen, J. J., Huey, W. S., Packard, G. A., Jr., Ryan, D. M., Burke, C. S., Smith, D. G., Watola, D. J., Pinder, E. D., Yosick, T. M., Estrada, A. X., Crepeau, L., & Bowles, S. V. (2013). Total Force Fitness in units part 1: military demand-resource model. *Journal of Military Medicine 178*(11), 1164-1182. https://doi.org/10.7205/milmed-d-12-00519

Blennow, K., Jonsson, M., Andreasen, N., Rosengren, L., Wallin, A., Hellstrom, P. A., & Zetterberg, H. (2011). No neurochemical evidence of brain injury after blast overpressure by repeated explosions or firing heavy weapons. *Acta Neurologica Scandinavia*, *123*(4), 245-251. https://doi.org/10.1111/j.1600-0404.2010.01408.x

Bliese, P. D., Thomas, J. L., McGurk, D., McBride, S., & Castro, C. A. (2011). Mental health advisory teams: a proactive examination of mental health during combat deployments. *International Review of Psychiatry*, *23*(2), 127-134. https://doi.org/10.3109/09540261.2011.558834

Bock, J. R., Russell, J., Hara, J., & Fortier, D. (2021). Optimizing Cognitive Assessment Outcome Measures for Alzheimer's Disease by Matching

Wordlist Memory Test Features to Scoring Methodology [Perspective]. *Frontiers in Digital Health*, *3*. https://doi.org/10.3389/fdgth.2021.750549

Bogdanova, Y., & Verfaellie, M. (2012). Cognitive sequelae of blast-induced traumatic brain injury: recovery and rehabilitation. *Neuropsycholgical Review*, *22*(1), 4-20. https://doi.org/10.1007/s11065-012-9192-3

Bono, J. E., Glomb, T. M., Shen, W., Kim, E., & Koch, A. J. (2013). Building Positive Resources: Effects of Positive Events and Positive Reflection on Work Stress and Health. *Academy of Management Journal*, *56*(6), 1601-1627. https://doi.org/10.5465/amj.2011.0272

Bozovic, D., Racic, M., & Ivkovic, N. (2013). Salivary cortisol levels as a biological marker of stress reaction. *Medical archives*, *67*(5), 374-377.

Brickenkamp, R., Schmidt-Atzert, L., & Liepmann, D. (2010). d2-R. In *Aufmerksamkeits- und Konzentrationstest)*. Göttingen, Germany: Hogrefe.

Brooks, S. K., & Greenberg, N. (2018). Non-deployment factors affecting psychological wellbeing in military personnel: literature review. *Journal of Mental Health*, *27*(1), 80-90. https://doi.org/10.1080/09638237.2016.1276536

Brounéus, K. (2014). On Return from Peacekeeping: A review of current research on psychological well-being in military personnel returning from operational deployment. *journal of Military and Veterans Health*, *22*(1), 24-29.

Buchanan, T. W., Tranel, D., & Adolphs, R. (2006). Impaired memory retrieval correlates with individual differences in cortisol response but not autonomic response. *Learning and Memory*, *13*(3), 382-387. https://doi.org/10.1101/lm.206306

Butcher, F. (2019). Role of research psychology in defence and security. *J R Army Med Corps*, *165*(2), 113. https://doi.org/10.1136/jramc-2018-001045

Campbell-Sills, L., Flynn, P. J., Choi, K. W., Ng, T. H. H., Aliaga, P. A., Broshek, C., Jain, S., Kessler, R. C., Stein, M. B., Ursano, R. J., & Bliese, P. D. (2022). Unit cohesion during deployment and post-deployment mental health: is cohesion an individual- or unit-level buffer for combat-exposed soldiers? *Psychological Medicine*, *52*(1), 121-131. https://doi.org/10.1017/s0033291720001786

Carr, W., Stone, J. R., Walilko, T., Young, L. A., Snook, T. L., Paggi, M. E., Tsao, J. W., Jankosky, C. J., Parish, R. V., & Ahlers, S. T. (2016). Repeated Low-Level Blast Exposure: A Descriptive Human Subjects Study. *Military Medicine*, *181*(5 Suppl), 28-39. https://doi.org/10.7205/milmed-d-15-00137

Chong, P. L. H., Garic, D., Shen, M. D., Lundgaard, I., & Schwichtenberg, A. J. (2022). Sleep, cerebrospinal fluid, and the glymphatic system: A systematic review. *Sleep Medicine Review*, *61*, 101572. https://doi.org/10.1016/j.smrv.2021.101572

Chu, B., Marwaha, K., Sanvictores, T., & Ayers, D. (2024). Physiology, Stress Reaction. In *StatPearls*. StatPearls Publishing Copyright © 2024, StatPearls Publishing LLC.

Clow, A., Edwards, S., Owen, G., Evans, G., Evans, P., Hucklebridge, F., & Casey, A. (2006). Post-awakening cortisol secretion during basic military training. *International Journal of Psychophysioly*, *60*(1), 88-94. https://doi.org/10.1016/j.ijpsycho.2005.05.007

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of health & social behavior*, *24*(4), 385-396.

Committee on Gulf War and Health: Physiologic, Psychologic, a. P. E. o., & Stress, D.-R. (2008). *Gulf War and Health: Volume 6. Physiologic,Psychologic, and Psychosocial Effects of Deployment-Related Stress*.

de Kloet, E. R., Oitzl, M. S., & Joëls, M. (1999). Stress and cognition: are corticosteroids good or bad guys? *Trends in Neurosciences*, *22*(10), 422-426. https://doi.org/10.1016/s0166-2236(99)01438-1

DeLongis, A., Coyne, J. C., Dakof, G., Folkman, S., & Lazarus, R. S. (1982). Relationship of daily hassles, uplifts, and major life events to health status. *Health Psychology*, *1*(2), 119-136. https://doi.org/10.1037/0278-6133.1.2.119

Dolezal, B. A., Neufeld, E. V., Boland, D. M., Martin, J. L., & Cooper, C. B. (2017). Interrelationship between Sleep and Exercise: A Systematic Review. *Advances in Preventive Medicine 2017*, 1364387. https://doi.org/10.1155/2017/1364387

Edwards, G., 3rd, Zhao, J., Dash, P. K., Soto, C., & Moreno-Gonzalez, I. (2020). Traumatic Brain Injury Induces Tau Aggregation and Spreading. *Journal of Neurotrauma 37*(1), 80-92. https://doi.org/10.1089/neu.2018.6348

Farnsworth, J. L., 2nd, Dargo, L., Ragan, B. G., & Kang, M. (2017). Reliability of Computerized Neurocognitive Tests for Concussion Assessment: A Meta-Analysis. *Journal of Athletic Training*, *52*(9), 826-833. https://doi.org/10.4085/1062-6050-52.6.03

Fear, N. T., Jones, M., Murphy, D., Hull, L., Iversen, A. C., Coker, B., Machell, L., Sundin, J., Woodhead, C., Jones, N., Greenberg, N., Landau, S., Dandeker, C., Rona, R. J., Hotopf, M., & Wessely, S. (2010). What are the consequences of deployment to Iraq and Afghanistan on the mental health of the UK armed forces? A cohort study. *Lancet*, *375*(9728), 1783-1797. https://doi.org/10.1016/s0140-6736(10)60672-1

Ferrier-Auerbach, A. G., Erbes, C. R., Polusny, M. A., Rath, C. M., & Sponheim, S. R. (2010). Predictors of emotional distress reported by soldiers in the combat zone. *Journal of Psychiatric Research 44*(7), 470-476. https://doi.org/10.1016/j.jpsychires.2009.10.010

Flanagan, S. C., Kotwal, R. S., & Forsten, R. D. (2012). Preparing soldiers for the stress of combat. *Journal of Special Operations Medicine*, *12*(2), 33-41.

Forbes, D., O'Donnell, M., Brand, R. M., Korn, S., Creamer, M., McFarlane, A. C., Sim, M. R., Forbes, A. B., & Hawthorne, G. (2016). The long-term mental health impact of peacekeeping: prevalence and predictors of psychiatric disorder. *British Journal of Psychiatry*, *2*(1), 32-37. https://doi.org/10.1192/bjpo.bp.115.001321

Fors Brandebo, M. (2020). Destructive leadership in crisis management. *Leadership & Organization Development Journal*, *41*(4), 567-580. https://doi.org/10.1108/LODJ-02-2019-0089

Franz, M. R., Wolf, E. J., MacDonald, H. Z., Marx, B. P., Proctor, S. P., & Vasterling, J. J. (2013). Relationships among predeployment risk factors, warzone-threat appraisal, and postdeployment PTSD symptoms. *Journal of Traumatic Stress*, *26*(4), 498-506. https://doi.org/10.1002/jts.21827

Försvarsmakten. (2022). *Militärstrategisk Doktrin MSD 22* https://www.forsvarsmakten.se/siteassets/2-om-forsvarsmakten/dokument/doktriner/msd-22.pdf

Gaetani, L., Blennow, K., Calabresi, P., Di Filippo, M., Parnetti, L., & Zetterberg, H. (2019). Neurofilament light chain as a biomarker in neurological disorders. *Journal of Neurology, Neurosurgery and Psychiatry*, *90*(8), 870-881. https://doi.org/10.1136/jnnp-2018-320106

Genter, R. (2015). Understanding the POW experience: stress research and the implementation of the 1955 U.S. Armed Forces Code of Conduct. *The Journal of the History of the Behavioural Sciences*, *51*(2), 141-163. https://doi.org/10.1002/jhbs.21696

Geuze, E., van Wingen, G. A., van Zuiden, M., Rademaker, A. R., Vermetten, E., Kavelaars, A., Fernandez, G., & Heijnen, C. J. (2012). Glucocorticoid receptor number predicts increase in amygdala activity after severe stress. *Psychoneuroendocrinology*, *37*(11), 1837-1844. https://doi.org/10.1016/j.psyneuen.2012.03.017

Goyal, A., Failla, M. D., Niyonkuru, C., Amin, K., Fabio, A., Berger, R. P., & Wagner, A. K. (2013). S100b as a prognostic biomarker in outcome prediction for patients with severe traumatic brain injury. *Journal of Neurotrauma 30*(11), 946-957. https://doi.org/10.1089/neu.2012.2579

Hacker Hughes, J., McCauley, M., & Wilson, L. (2019). History of military psychology. *Journal of the Royal Army Medical Corps 165*(2), 68-70. https://doi.org/10.1136/jramc-2018-001048

Harris, W. C., Hancock, P. A., & Harris, S. C. (2005). Information Processing Changes Following Extended Stress. *Military Psychology*, *17*(2), 115-128. https://doi.org/10.1207/s15327876mp1702_4

Haydabrus, A., Santana-Santana, M., Lazarenko, Y., & Giménez-Llort, L. (2022). Current War in Ukraine: Lessons from the Impact of War on Combatants' Mental Health during the Last Decade. *nternational Journal of*

Environmental Research and Public Health, *19*(17). https://doi.org/10.3390/ijerph191710536

Hellhammer, D. H., Wust, S., & Kudielka, B. M. (2009). Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology*, *34*(2), 163-171. https://doi.org/10.1016/j.psyneuen.2008.10.026

Henning, P. C., Park, B. S., & Kim, J. S. (2011). Physiological decrements during sustained military operational stress. *Military Medicine 176*(9), 991-997. (Mil Med)

Heron, E. A., Bryan, C. J., Dougherty, C. A., & Chapman, W. G. (2013). Military mental health: the role of daily hassles while deployed. *Journal of Nervous and Mental Disease*, *201*(12), 1035-1039. https://doi.org/10.1097/nmd.0000000000000058

Inoue, C., Shawler, E., Jordan, C. H., Moore, M. J., & Jackson, C. A. (2024). Veteran and Military Mental Health Issues. In *StatPearls*. StatPearls Publishing

Copyright © 2024, StatPearls Publishing LLC.

Iverson, G. L., Ivins, B. J., Karr, J. E., Crane, P. K., Lange, R. T., Cole, W. R., & Silverberg, N. D. (2019). Comparing Composite Scores for the ANAM4 TBI-MIL for Research in Mild Traumatic Brain Injury. *Archives of Clinical Neuropsychology*, *35*(1), 56-69. https://doi.org/10.1093/arclin/acz021

James, K. A., Stromin, J. I., Steenkamp, N., & Combrinck, M. I. (2023). Understanding the relationships between physiological and psychosocial stress, cortisol and cognition. *Frontiers in Endocrinology*, *14*, 1085950. https://doi.org/10.3389/fendo.2023.1085950

Jessen, N. A., Munk, A. S., Lundgaard, I., & Nedergaard, M. (2015). The Glymphatic System: A Beginner's Guide. *Neurochemical Research*, *40*(12), 2583-2599. https://doi.org/10.1007/s11064-015-1581-6

Jones, N., Mitchell, P., Clack, J., Fertout, M., Fear, N. T., Wessely, S., & Greenberg, N. (2014). Mental health and psychological support in UK armed forces personnel deployed to Afghanistan in 2010 and 2011. *The British journal of psychiatry 204*(2), 157-162. https://doi.org/10.1192/bjp.bp.113.131433

Jones, N., Seddon, R., Fear, N. T., McAllister, P., Wessely, S., & Greenberg, N. (2012). Leadership, cohesion, morale, and the mental health of UK Armed Forces in Afghanistan. *Psychiatry*, *75*(1), 49-59. https://doi.org/10.1521/psyc.2012.75.1.49

Jouanin, J. C., Dussault, C., Peres, M., Satabin, P., Pierard, C., & Guezennec, C. Y. (2004). Analysis of heart rate variability after a ranger training course. *Military Medicine*, *169*(8), 583-587.

Juster, R. P., & McEwen, B. S. (2015). Sleep and chronic stress: new directions for allostatic load research. *Sleep Medicine 16*(1), 7-8. https://doi.org/10.1016/j.sleep.2014.07.029

Juster, R. P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neuroscience & Biobehavioral Reviews*, *35*(1), 2-16. https://doi.org/10.1016/j.neubiorev.2009.10.002

Kaikkonen, N. M., & Laukkala, T. (2016). International military operations and mental health--A review. *Nordic Journal of Psychiatry*, *70*(1), 10-15. https://doi.org/10.3109/08039488.2015.1048718

Kamimori, G. H., Reilly, L. A., LaValle, C. R., & Olaghere Da Silva, U. B. (2017). Occupational overpressure exposure of breachers and military personnel. *Shock waves*, *27*(6), 837-847. https://doi.org/10.1007/s00193-017-0738-4

Kanner, A. D., Coyne, J. C., Schaefer, C., & Lazarus, R. S. (1981). Comparison of two modes of stress measurement: daily hassles and uplifts versus major life events. *Journal of Behavioral Medicine 4*(1), 1-39.

Kecklund, G. Å., T. (2018). *Karolinska Sleep Questionaire (KSQ)*. Stress Research Institute.

Kirschbaum, C., & Hellhammer, D. H. (1989). Salivary cortisol in psychobiological research: an overview. *Neuropsychobiology*, *22*(3), 150-169. https://doi.org/118611

Kokun, O., Pischko, I., & Lozinska, N. (2023). Military personnel's stress reactivity during pre-deployment in a war zone. *Psychology, Health & Medicine 28*(8), 2341-2352. https://doi.org/10.1080/13548506.2022.2104882

Lande, R. (2014). Stress in service members. *Psychiatric Clinics of North America*, *37*(4), 547-560.

Larsson, G., Berglund, A. K., & Ohlsson, A. (2016). Daily hassles, their antecedents and outcomes among professional first responders: A systematic literature review. *Scandinavian Journal of Psychology 57*(4), 359-367. https://doi.org/10.1111/sjop.12303

Larsson, G., Berglund, A. K., Ohlsson, & Nilsson. S (2017). Daily uplifts and coping as a buffer against everyday hassles: Relationship with stress reactions over time in military personnel. *Scandinavian Psychologist*, *4*(e 13).

Lathan, C., Spira, J. L., Bleiberg, J., Vice, J., & Tsao, J. W. (2013). Defense Automated Neurobehavioral Assessment (DANA)-psychometric properties of a new field-deployable neurocognitive assessment tool. *Military Medicine*, *178*(4), 365-371. https://doi.org/10.7205/milmed-d-12-00438

LaValle, C. R., Carr, W. S., Egnoto, M. J., Misistia, A. C., Salib, J. E., Ramos, A. N., & Kamimori, G. H. (2019). Neurocognitive Performance Deficits Related to Immediate and Acute Blast Overpressure Exposure. *Frontiers in Neurology*, *10*, 949. https://doi.org/10.3389/fneur.2019.00949

Law, R., & Clow, A. (2020). Stress, the cortisol awakening response and cognitive function. *International Review of Neurobiology*, *150*, 187-217. https://doi.org/10.1016/bs.irn.2020.01.001

Lazarus, R. S. (1991). *Emotion and adaptation*. Oxford University Press.

Lazarus, R. S. (1999). *Stress and emotion: A new synthesis*. Springer Publishing Co.

Lefevre-Dognin, C., Cogné, M., Perdrieau, V., Granger, A., Heslot, C., & Azouvi, P. (2021). Definition and epidemiology of mild traumatic brain injury. *Neurochirurgie*, *67*(3), 218-221. https://doi.org/10.1016/j.neuchi.2020.02.002

Lennartsson, A. K., Sjors, A., Wahrborg, P., Ljung, T., & Jonsdottir, I. H. (2015). Burnout and Hypocortisolism - A Matter of Severity? A Study on ACTH and Cortisol Responses to Acute Psychosocial Stress. *Frontiers in Psychiatry*, *6*, 8. https://doi.org/10.3389/fpsyt.2015.00008

Lieberman, H. R., Bathalon, G. P., Falco, C. M., Kramer, F. M., Morgan, C. A., 3rd, & Niro, P. (2005). Severe decrements in cognition function and mood induced by sleep loss, heat, dehydration, and undernutrition during simulated combat. *Biological Psychiatry* *57*(4), 422-429. https://doi.org/10.1016/j.biopsych.2004.11.014

Lieberman, H. R., Bathalon, G. P., Falco, C. M., Morgan, C. A., Niro, P. J., & Tharion, W. J. (2005). The fog of war: decrements in cognitive performance and mood associated with combat-like stress. *Aviation, Space, and Environmental Medicine* *76*(7 Suppl), C7-14.

Lieberman, H. R., Castellani, J. W., & Young, A. J. (2009). Cognitive Function and Mood During Acute Cold Stress After Extended Military Training and Recovery. *Aviation Space and Environmental Medicine*, *80*(7), 629-636. https://doi.org/10.3357/asem.2431.2009

Lieberman, H. R., Farina, E. K., Caldwell, J., Williams, K. W., Thompson, L. A., Niro, P. J., Grohmann, K. A., & McClung, J. P. (2016). Cognitive function, stress hormones, heart rate and nutritional status during simulated captivity in military survival training. *Physiology and Behavior*, *165*, 86-97. https://doi.org/10.1016/j.physbeh.2016.06.037

Lieberman, H. R., Niro, P., Tharion, W. J., Nindl, B. C., Castellani, J. W., & Montain, S. J. (2006). Cognition during sustained operations: Comparison of a laboratory simulation to field studies. *Aviation Space and Environmental Medicine*, *77*(9), 929-935.

Liu, Y., Zhu, S. H., Wang, G. H., Ye, F., & Li, P. Z. (2013). Validity and reliability of multiparameter physiological measurements recorded by the Equivital LifeMonitor during activities of various intensities. *Journal of Occupational and Environmental Hygiene,*, *10*(2), 78-85. https://doi.org/10.1080/15459624.2012.747404

Lundgren-Nilsson, A., Jonsdottir, I. H., Pallant, J., & Ahlborg, G., Jr. (2012). Internal construct validity of the Shirom-Melamed Burnout Questionnaire (SMBQ). *BMC Public Health*, *12*, 1. https://doi.org/10.1186/1471-2458-12-1

Lupien, S. J., Maheu, F., Tu, M., Fiocco, A., & Schramek, T. E. (2007). The effects of stress and stress hormones on human cognition: Implications for the field of brain and cognition. *Brain and Cognition 65*(3), 209-237. https://doi.org/10.1016/j.bandc.2007.02.007

Lyk-Jensen, S. V., Weatherall, C. D., & Jepsen, P. W. (2016). The effect of military deployment on mental health. *Economics & Human Biology*, *23*, 193-208. https://doi.org/10.1016/j.ehb.2016.09.005

Makhani, A., Akbaryan, F., & Cernak, I. (2015). Cognitive performance improvement in Canadian Armed Forces personnel during deployment. *Journal of Military, Veteran and Family Health 1*, 59-67. https://doi.org/10.3138/jmvfh.2014-04

Makras, P., Koukoulis, G. N., Bourikas, G., Papatheodorou, G., Bedevis, K., Menounos, P., Pappas, D., & Kartalis, G. (2005). Effect of 4 weeks of basic military training on peripheral blood leucocytes and urinary excretion of catecholamines and cortisol. *Journal of Sports Sciences 23*(8), 825-834. https://doi.org/10.1080/02640410400021815

Matsuda, S., Yamaguchi, T., Okada, K., Gotouda, A., & Mikami, S. (2012). Day-to-day variations in salivary cortisol measurements. *Journal of Prosthodontic Research 56*(1), 37-41. https://doi.org/10.1016/j.jpor.2011.04.004

Matthew, G., Meek, D., Gibbs, T., Sawford, H., Wessely, S., & Greenberg, N. (2015). What are the psychological effects of delivering and receiving "high-risk" survival resistance training? *Military Medicine*, *180*(2), 168-177. https://doi.org/10.7205/milmed-d-14-00285

McCabe, C. T., Watrous, J. R., Eskridge, S. L., & Galarneau, M. R. (2021). Mental and physical health, and long-term quality of life among service members injured on deployment. *Health Qual Life Outcomes*, *19*(1), 220. https://doi.org/10.1186/s12955-021-01852-3

McCauley, M., & Breeze, J. (2019). Dispatches from the editor: military psychology, a force multiplier. *Journal of the Royal Army Medical Corps 165*(2), 63-64. https://doi.org/10.1136/jramc-2018-001110

McDonald, S. D., Walker, W. C., Cusack, S. E., Yoash-Gantz, R. E., Pickett, T. C., Cifu, D. X., Mid-Atlantic Mirecc Workgroup, V., & Tupler, L. A. (2021). Health symptoms after war zone deployment-related mild traumatic brain injury: contributions of mental disorders and lifetime brain injuries. *Brain Injury,, 35*(11), 1338-1348. https://doi.org/10.1080/02699052.2021.1959058

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine*, *338*(3), 171-179. https://doi.org/10.1056/nejm199801153380307

McEwen, B. S. (2012). Brain on stress: how the social environment gets under the skin. *Proceedings of the National Academy of Sciences*, *109 Suppl 2*, 17180-17185. https://doi.org/10.1073/pnas.1121254109

McEwen, B. S. (2013). The Brain on Stress: Toward an Integrative Approach to Brain, Body, and Behavior. *Perspectives on Psychological Science 8*(6), 673-675. https://doi.org/10.1177/1745691613506907

McEwen, B. S. (2016). In pursuit of resilience: stress, epigenetics, and brain plasticity. *Annals of the New York Academy of Sciences 1373*(1), 56-64. https://doi.org/10.1111/nyas.13020

McEwen, B. S., Bowles, N. P., Gray, J. D., Hill, M. N., Hunter, R. G., Karatsoreos, I. N., & Nasca, C. (2015). Mechanisms of stress in the brain. *Nature Neuroscience 18*(10), 1353-1363. https://doi.org/10.1038/nn.4086

McEwen, B. S., & Karatsoreos, I. N. (2015). Sleep Deprivation and Circadian Disruption: Stress, Allostasis, and Allostatic Load. *Sleep Medicine Clinics 10*(1), 1-10. https://doi.org/10.1016/j.jsmc.2014.11.007

McEwen, B. S., & Sapolsky, R. M. (1995). Stress and cognitive function. *Current Opinion in Neurobiology 5*(2), 205-216. https://doi.org/10.1016/0959-4388(95)80028-x

Medic, G., Wille, M., & Hemels, M. E. (2017). Short- and long-term health consequences of sleep disruption. *Nature and Science of Sleep 9*, 151-161. https://doi.org/10.2147/nss.S134864

Meichenbaum, D., & Novaco, R. (1985). Stress inoculation: a preventative approach. *Issues in Mental Health Nursing 7*(1-4), 419-435. https://doi.org/10.3109/01612848509009464

Menon, D. K., Schwab, K., Wright, D. W., & Maas, A. I. (2010). Position Statement: Definition of Traumatic Brain Injury. *Archives of Physical Medicine and Rehabilitation*, *91*(11), 1637-1640. https://doi.org/https://doi.org/10.1016/j.apmr.2010.05.017

Mestre, H., Mori, Y., & Nedergaard, M. (2020). The Brain's Glymphatic System: Current Controversies. *Trends in Neurosciences 43*(7), 458-466. https://doi.org/10.1016/j.tins.2020.04.003

Michel, P. O., Lundin, T., & Larsson, G. (2003). Stress reactions among Swedish peacekeeping soldiers serving in Bosnia: a longitudinal study. *Journal of Traumatic Stress.* , *16*(6), 589-593. https://doi.org/10.1023/b:Jots.0000004084.85732.86

Michel, P. O., Lundin, T., & Larsson, G. (2007). Suicide rate among former Swedish peacekeeping personnel. *Military Medicine.* , *172*(3), 278-282. https://doi.org/10.7205/milmed.172.3.278

Mulligan, K., Fear, N. T., Jones, N., Wessely, S., & Greenberg, N. (2011). Psycho-educational interventions designed to prevent deployment-related psychological ill-health in Armed Forces personnel: a review. *Psychological Medicine.* , *41*(4), 673-686. https://doi.org/10.1017/s003329171000125x

Nordin, M., Åkerstedt, T., & Nordin, S. (2013). Psychometric evaluation and normative data for the Karolinska Sleep Questionnaire. *Sleep and biological rhythms*, *11*(4), 216-226. https://doi.org/10.1111/sbr.12024

Perski, A. (2013). *Stressmottagningen*. Retrieved 20211022 from https://stressmottagningen.se/en/in-english/

Peters, A., & McEwen, B. S. (2012). Introduction for the allostatic load special issue. *Physiology and Behavior*, *106*(1), 1-4. https://doi.org/10.1016/j.physbeh.2011.12.019

Pethrus, C. M., Johansson, K., Neovius, K., Reutfors, J., Sundstrom, J., & Neovius, M. (2017). Suicide and all-cause mortality in Swedish deployed military veterans: a population-based matched cohort study. *BMJ Open*, *7*(9), e014034. https://doi.org/10.1136/bmjopen-2016-014034

Pierard, C., Beracochea, D., Peres, M., Jouanin, J. C., Liscia, P., Satabin, P., Martin, S., Testylier, G., Guezennec, C. Y., & Beaumont, M. (2004). Declarative memory impairments following a military combat course: Parallel neuropsychological and biochemical investigations. *Neuropsychobiology*, *49*(4), 210-217. https://doi.org/10.1159/000077369

Pietrzak, E., Pullman, S., Cotea, C., & Nasveld, P. (2013). Effects of deployment on health behaviours in military forces: A review of longitudinal studies. *Journal of Military and Veterans' Health*, *21*(1), 9.

Prykhodko, I. (2022). The model of psychological safety of a soldier's personality. *Current Issues in Personality Psychology.* , *10*(2), 112-122. https://doi.org/10.5114/cipp.2021.108684

Pulopulos, M. M., Baeken, C., & De Raedt, R. (2020). Cortisol response to stress: The role of expectancy and anticipatory stress regulation. *Hormones and Behavior 117*, 104587. https://doi.org/10.1016/j.yhbeh.2019.104587

Ragsdale, K. A., Nichols, A. A., Mehta, M., Maples-Keller, J. L., Yasinski, C. W., Hyatt, C. S., Watkins, L. E., Loucks, L. A., Carbone, E., Rauch, S. A. M., & Rothbaum, B. O. (2024). Comorbid treatment of traumatic brain injury and mental health disorders. *NeuroRehabilitation*, 1-10. https://doi.org/10.3233/NRE-230235

Raju, M. S. (2014). Psychological aspects of peacekeeping operations. *Indian Journal of Psychiatry*, *23*(2), 149-156. https://doi.org/10.4103/0972-6748.151693

Reisberg, B., Ferris, S. H., de Leon, M. J., & Crook, T. (1982). The Global Deterioration Scale for assessment of primary degenerative dementia. *American Journal of Psychiatry*, *139*(9), 1136-1139. https://doi.org/10.1176/ajp.139.9.1136

Reznick, A. Z. (1989). The cycle of stress--a circular model for the psychobiological response to strain and stress. *Medical Hypotheses*, *30*(3), 217-222. https://doi.org/10.1016/0306-9877(89)90064-9

Rice, V. J., Lindsay, G., Overby, C. R., Jeter, A., Alfred, P., Boykin, G. L., Vilbiss, C. D., & Bateman, R. (2011). Automated Neuropsychological Assessment Metrics (ANAM) Traumatic Brain Injury (TBI): Human Factors Assessment.

Robson, S., & Manacapilli, T. (2014). *Enhancing Performance Under Stress: Stress Inoculation Training for Battlefield Airmen* [reserch rapport]. RAND Corporation, Air Force.

Roebuck-Spencer, T., Sun, W., Cernich, A. N., Farmer, K., & Bleiberg, J. (2007). Assessing change with the Automated Neuropsychological Assessment Metrics (ANAM): Issues and challenges. *Archives of Clinical Neuropsychology*, *22*, 79-87. https://doi.org/https://doi.org/10.1016/j.acn.2006.10.011

Rom, O., & Reznick, A. Z. (2016). The Stress Reaction: A Historical Perspective. *Advances in Experimental Medicine and Biology*, *905*, 1-4. https://doi.org/10.1007/5584_2015_195

Rona, R. J., Burdett, H., Khondoker, M., Chesnokov, M., Green, K., Pernet, D., Jones, N., Greenberg, N., Wessely, S., & Fear, N. T. (2017). Post-deployment screening for mental disorders and tailored advice about help-seeking in the UK military: a cluster randomised controlled trial. *Lancet*, *389*(10077), 1410-1423. https://doi.org/10.1016/s0140-6736(16)32398-4

Russell, G., & Lightman, S. (2019). The human stress response. *Nature Reviews Endocrinology 15*(9), 525-534. https://doi.org/10.1038/s41574-019-0228-0

Sajja, V., LaValle, C., Salib, J. E., Misistia, A. C., Ghebremedhin, M. Y., Ramos, A. N., Egnoto, M. J., Long, J. B., & Kamimori, G. H. (2019). The Role of Very Low Level Blast Overpressure in Symptomatology. *Frontiers in Neurology*, *10*, 891. https://doi.org/10.3389/fneur.2019.00891

Sapolsky, R. M. (2015). Stress and the brain: individual variability and the inverted-U. *Nature Neuroscience 18*(10), 1344-1346. https://doi.org/10.1038/nn.4109

Sapolsky, R. M., Krey, L. C., & McEwen, B. S. (1986). The neuroendocrinology of stress and aging: the glucocorticoid cascade hypothesis. *Endocrine Reviews*, *7*(3), 284-301. https://doi.org/10.1210/edrv-7-3-284

Sareen, J., Belik, S. L., Afifi, T. O., Asmundson, G. J., Cox, B. J., & Stein, M. B. (2008). Canadian military personnel's population attributable fractions of mental disorders and mental health service use associated with combat and peacekeeping operations. *American Journal of Public Health 98*(12), 2191-2198. https://doi.org/10.2105/ajph.2008.134205

Sareen, J., Cox, B. J., Afifi, T. O., Stein, M. B., Belik, S. L., Meadows, G., & Asmundson, G. J. (2007). Combat and peacekeeping operations in relation to prevalence of mental disorders and perceived need for mental health care: findings from a large representative sample of military personnel. *Archives Of General Psychiatry 64*(7), 843-852. https://doi.org/10.1001/archpsyc.64.7.843

Sareen, J., Stein, M. B., Thoresen, S., Belik, S. L., Zamorski, M., & Asmundson, G. J. (2010). Is peacekeeping peaceful? A systematic review. *The Canadian Journal of Psychiatry*, *55*(7), 464-472.

Schlotz, W., Hammerfald, K., Ehlert, U., & Gaab, J. (2011). Individual differences in the cortisol response to stress in young healthy men: testing the roles of perceived stress reactivity and threat appraisal using multiphase latent growth curve modeling. *Biological Psychology*, *87*(2), 257-264. https://doi.org/10.1016/j.biopsycho.2011.03.005

Segerstrom, S. C., Sephton, S. E., & Westgate, P. M. (2017). Intraindividual variability in cortisol: Approaches, illustrations, and recommendations. *Psychoneuroendocrinology*, *78*, 114-124. https://doi.org/10.1016/j.psyneuen.2017.01.026

Selye, H. (1936). A Syndrome produced by Diverse Nocuous Agents. *Nature*, *138*(3479), 32-32. https://doi.org/10.1038/138032a0

Shahim, P., Tegner, Y., Wilson, D. H., Randall, J., Skillback, T., Pazooki, D., Kallberg, B., Blennow, K., & Zetterberg, H. (2014). Blood biomarkers for brain injury in concussed professional ice hockey players. *JAMA Neurology 71*(6), 684-692. https://doi.org/10.1001/jamaneurol.2014.367

Sharpley, J. G., Fear, N. T., Greenberg, N., Jones, M., & Wessely, S. (2008). Pre-deployment stress briefing: does it have an effect? *Occupational Medicine*, *58*(1), 30-34. https://doi.org/10.1093/occmed/kqm118

Shigemura, J., Nagamine, M., Harada, N., Tanichi, M., Shimizu, K., & Yoshino, A. (2016). Peacekeepers deserve more mental health research and care. *The British Journal of Psychiatry Open*, *2*(2), e3-e4. https://doi.org/10.1192/bjpo.bp.115.002410

Shigemura, J., & Nomura, S. (2002). Mental health issues of peacekeeping workers. *Psychiatry and Clinical Neurosciences 56*(5), 483-491. https://doi.org/10.1046/j.1440-1819.2002.01043.x

Shirom, A., & Melamed, S. (2006). A comparison of the construct validity of two burnout measures in two groups of professionals. *International Journal of Stress Management*, *13*(2), 176-200. https://doi.org/10.1037/1072-5245.13.2.176

Silva, M. A. (2021). Review of the Neurobehavioral Symptom Inventory. *Rehabilitation Psychology*, *66*(2), 170-182. https://doi.org/10.1037/rep0000367

Staal, M. A., & DeVries, M. R. (2020). Military operational psychology. *Psychological Services 17*(2), 195-198. https://doi.org/10.1037/ser0000308

Staal, M. A., & Stephenson, J. A. (2013). Operational Psychology Post-9/11: A Decade of Evolution. *Military Psychology*, *25*(2), 93-104. https://doi.org/10.1037/h0094951

Stern, R. A., & White, T. (2004). NAB Digits Forward/Digits Backward Test)'. In. Florida, U.S.A: Hogrefe.

Suurd Ralph, C., Vartanian, O., Lieberman, H. R., Morgan, C. A., 3rd, & Cheung, B. (2017). The effects of captivity survival training on mood, dissociation, PTSD symptoms, cognitive performance and stress hormones. *International Journal of Psychophysiology*, *117*, 37-47. https://doi.org/10.1016/j.ijpsycho.2017.04.002

Tate, C. M., Wang, K. K., Eonta, S., Zhang, Y., Carr, W., Tortella, F. C., Hayes, R. L., & Kamimori, G. H. (2013). Serum Brain Biomarker Level, Neurocognitive Performance, and Self-Reported Symptom Changes in Soldiers Repeatedly Exposed to Low-Level Blast: A Breacher Pilot Study. *Journal of Neurotrauma* https://doi.org/10.1089/neu.2012.2683

van Wingen, G. A., Geuze, E., Vermetten, E., & Fernandez, G. (2011). Perceived threat predicts the neural sequelae of combat stress. *Molecular Psychiatry 16*(6), 664-671. https://doi.org/10.1038/mp.2010.132

Varanoske, A. N., McClung, H. L., Sepowitz, J. J., Halagarda, C. J., Farina, E. K., Berryman, C. E., Lieberman, H. R., McClung, J. P., Pasiakos, S. M., & Philip Karl, J. (2022). Stress and the gut-brain axis: Cognitive performance, mood state, and biomarkers of blood-brain barrier and intestinal permeability following severe physical and psychological stress. *Brain, behavior, and immunity*, *101*, 383-393. https://doi.org/10.1016/j.bbi.2022.02.002

Vartanian, O., Tenn, C., Rhind, S. G., Nakashima, A., Di Battista, A. P., Sergio, L. E., Gorbet, D. J., Fraser, D. D., Colantonio, A., King, K., Lam, Q., Saunders, D., & Jetly, R. (2020). Blast in Context: The Neuropsychological and Neurocognitive Effects of Long-Term Occupational Exposure to Repeated Low-Level Explosives on Canadian Armed Forces' Breaching Instructors and Range Staff. *Frontiers in Neurology 11*, 588531. https://doi.org/10.3389/fneur.2020.588531

Vasterling, J. J., Verfaellie, M., & Sullivan, K. D. (2009). Mild traumatic brain injury and posttraumatic stress disorder in returning veterans: perspectives from cognitive neuroscience. *Clinical Psychology Review*, *29*(8), 674-684. https://doi.org/10.1016/j.cpr.2009.08.004

Verrall, N. (2019). Psychology, risk, health and deployed military operations. *Journal of the Royal Army Medical Corps 165*(2), 116-119. https://doi.org/10.1136/jramc-2018-001043

Vrijkotte, S., Valk, P. J., Veenstra, B. J., & Visser, T. (2009). *Monitoring Physical and Cognitive Performance During Sustained Military Operations*. T. D. S. A. S. S. (NETHERLANDS).

Waller, M., Treloar, S. A., Sim, M. R., McFarlane, A. C., McGuire, A. C., Bleier, J., & Dobson, A. J. (2012). Traumatic events, other operational stressors and physical and mental health reported by Australian Defence Force personnel following peacekeeping and war-like deployments. *BMC Psychiatry*, *12*, 88. https://doi.org/10.1186/1471-244x-12-88

Wang, K. K., Yang, Z., Zhu, T., Shi, Y., Rubenstein, R., Tyndall, J. A., & Manley, G. T. (2018). An update on diagnostic and prognostic biomarkers for traumatic brain injury. *Expert Review of Molecular Diagnostics*, *18*(2), 165-180. https://doi.org/10.1080/14737159.2018.1428089

Weeks, S. R., McAuliffe, C. L., DuRussel, D., & Pasquina, P. F. (2010). Physiological and Psychological Fatigue in Extreme Conditions: The Military Example. *Physical medicine and rehabilitation*, *2*(5), 438-441. https://doi.org/10.1016/j.pmrj.2010.03.023

Wells, T. S., Miller, S. C., Adler, A. B., Engel, C. C., Smith, T. C., & Fairbank, J. A. (2011). Mental health impact of the Iraq and Afghanistan conflicts: a review of US research, service provision, and programmatic responses. *International Review of Psychiatry*, *23*(2), 144-152. https://doi.org/10.3109/09540261.2011.558833

Wust, S., Wolf, J., Hellhammer, D. H., Federenko, I., Schommer, N., & Kirschbaum, C. (2000). The cortisol awakening response - normal values and confounds. *Noise Health*, *2*(7), 79-88.