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# **Mindfulness in High Performance Environments**

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## Summary

**Introduction:** Being mindful and mindfulness-training have been associated with improved attention control and stress-reduction in the normal population. However, little is known about the effects of such training in high performance cohorts.

**Aim:** The main aim of this thesis was to explore the feasibility and effects of mindfulness-training (MT) in elite cohorts operating in dynamic and taxing environments. We sought to highlight aspects related to feasibility, stress-reduction and the inhibition aspect of executive functions.

**The studies:** This thesis comprises four studies (N = 107). The first study examined the feasibility of MT in a high-performance cohort. The study involved pre to post changes and long-term effects of 12 months of MT in a male high-performance combat aircraft cohort (n = 21), using self-report measures of mindfulness, mental skills and anxiety, followed by post-intervention interviews, and two-year follow-up. In the second study we investigated whether a computerised go/no-go test could be a reliable measure of changes in response-inhibition during whole body vibration in elite orienteering-runners (n = 19). In the third study we sought to determine if a 4-month MT intervention had a measurable impact on stress and inhibitory functioning in military aviation personnel (n = 40) during a period of prolonged high-workloads. This was a controlled study comprising two military helicopter units during their deployment-periods. Personnel in one squadron (n = 25) received MT, while personnel in the other squadron (n = 15) acted as wait-list controls. We used the same go/no-go test as in study 2 to test response inhibition, and also included a test of inhibition of stimulus-driven attentional capture. Stress-reduction was measured using saliva cortisol and self-reported mental demand on the go/no-go test. In the fourth study we investigated the association between different facets of mindfulness and inhibitory control in professional soccer players (n = 42), not yet exposed to MT, using the same computerised tests as in study 3.

**Main results:** In study 1, there was a pre- to post-improvement in self-reported mindfulness, attention regulation, emotion regulation, and a reduction in performance related somatic anxiety. Participants reported a high degree of acceptance and satisfaction with the programme. Mindfulness scores remained elevated throughout the two-year follow-up. In study 2 we found that the go/no-go test was sensitive to subtle decrements in response inhibition during whole body vibration. In paper 3, the results from a mixed between-within analysis revealed that the MT participants, compared to controls, had a larger pre to post increase in high- and low-cortisol slopes, together with decreased perceived mental demand imposed by the go/no-go test. No pre to post changes were found in performance on any of the computerised tests. The main findings in study 4 were that in MT-naïve professional soccer players, higher scores on the observation facet of mindfulness were associated with improved inhibitory control and perceptual flexibility, while higher scores on the non-judgement facet were associated with a loss of inhibitory control and more impulsive responding.

**Conclusions:** Overall, the findings indicated that MT alleviates some of the physiological and psychological stress of challenging tasks and periods of high workloads. The results from the follow-up in study 1 also indicated that these effects may be long lasting. Inhibitory functioning, as measured in the current thesis, was differentially related to mindfulness-facets in MT-naïve participants, but was not readily improved by a 4-month MT programme.

**Applied implications:** These findings are important as MT interventions could be a useful method for protection against fatigue and attrition effects of extended periods of high workload, supporting the vision of MT as a promising technique for promoting resilience in high-performance groups. However, MT in the form that was studied in the current research was not an efficient measure to improve the inhibition element of executive functioning, at

least not at the level of preventing interference from stimulus-driven attentional capture or stopping motor action. Methodologically, the current research underscores the importance of multidimensional measures of mindfulness and demonstrates that the computerised tests used may be easily accessible and useful markers of response inhibition and inhibition of automatic task-irrelevant stimulus processing in elite cohorts. There is a need for future randomized controlled trials (RCTs), with active control groups to further assess the effect of MT in high performance environments. Qualitative research should also be undertaken to further develop the mechanisms and processes of becoming more mindful in these environments.

**Keywords:** Mindfulness, high-performance, stress, cortisol, executive control, inhibition, mental skills



## Sammendrag

**Bakgrunn:** Å være mindful og å delta i mindfulness-trening (MT) har blitt assosiert med økt oppmerksomhet og stress-reduksjon i enkelte grupper, men det finnes lite kunnskap om effektene av slik trening i høyprestasjonsmiljøer.

**Hensikt:** Hovedmålet med denne avhandlingen var å undersøke effektene av MT i elite grupper som må prestere optimalt i dynamiske og krevende miljøer. Vi fokuserte på aspekter relatert til gjennomførbarhet, stress-reduksjon og inhibisjons-elementet (evne til å stoppe/kontrollere automatiserte responser) av vårt overordnede kontroll system.

**Studiene:** Avhandlingen består av 4 studier (N = 107). Den første studien tar for seg gjennomførbarheten av MT i en høyprestasjons gruppe. Vi undersøkte pre- til post-endringer og langsiktige effekter av 12 måneder MT i en jagerflyskvadron (n = 21). Vi benyttet selvrapporterte mål for mindfulness, mentale ferdigheter, og prestasjonsangst, etterfulgt av post-intervensjons intervjuer, med oppfølgingsmålinger ett og to år etter avsluttet intervensjon.

I den andre studien undersøkte vi om en computerbasert «go/no-go» test kunne være et reliabelt mål på endringer i respons-inhibisjon under helkroppss vibrasjon hos elite orienteringsløpere (n = 19). I den tredje studien undersøkte vi om en 4-måneders lang MT intervensjon hadde effekt på stress og inhibisjon i militært flyoperativt personell (n = 40) under langvarig høy arbeidsbelastning. Vi benyttet den samme «go/no-go» testen som i studie 2 for å teste respons inhibisjon. I tillegg til en computerbasert 'attentional capture task' for å teste effekten av MT på inhibisjon av prosessering av oppgave-irrelevante stimuli (i.e. rødt blink). Stress-reduksjon ble målt ved hjelp av cortisol i spytt, samt grad av selvrapportert mental innsats på go/no-go testen. Dette var en kontrollert studie med to militære helikopter skvadroner under deployering. Personellet i en skvadron (n = 25) fikk MT, imens personellet i den andre skvadronen (n = 15) fungerte som venteliste kontroll gruppe. I den fjerde studien benyttet vi de samme computerbaserte testene som i studie 3 for å undersøke sammenhengen

mellom de forskjellige fasettene av mindfulness og inhibisjon i profesjonelle fotball spillere (n = 42), før de ble utsatt for MT.

**Resultater:** Deltakerne i studie 1 rapporterte en høy grad av aksept og tilfredshet med MT programmet. Vi fant en pre- til post-forbedring i selvrapportert mindfulness, oppmerksomhetsregulering, emosjonsregulering og en reduksjon i prestasjonsrelatert somatisk angst. Mindfulness scorene forble forhøyet gjennom de to årene med oppfølgings målinger. I studie 2 fant vi at go/no-go testen var sensitiv til svekkelser i respons inhibisjon under helkroppsvibrasjon. I studie 3 viste resultatene fra en mixed between-within analyse at MT deltakerne, sammenlignet med kontroll, hadde en større pre til post økning i høy- og lav-cortisol “slopes”, og at de opplevde go/no-go testen som mindre krevende. Ingen pre til post endringer i prestasjon ble funnet på noen av de computerbaserte testene. I studie 4 fant vi at høyere scorer på observasjon-fasetten av mindfulness var assosiert med forbedret inhibisjon og perseptuell fleksibilitet målt med de computerbaserte testene hos profesjonelle fotballspillere. Høyere scorer på ikke-dømming fasetten av mindfulness var derimot assosiert med lavere scorer og mer impulsiv respondering på testene.

**Konklusjon:** Tilsammen indikerer disse funnene at MT kan avhjelpe noe av det potensielle fysiologiske og psykologiske stresset som følger med utfordrende oppgaver og perioder med høy arbeidsbelastning. Resultatene fra oppfølgingsmålingene i studie 1 indikerer at effektene av MT også kan være langvarige i høyprestasjonsgrupper. Inhibisjon, slik vi målte den i de aktuelle studiene, kan være både positivt og negativt assosiert med mindfulness, samtidig lar det seg ikke lett påvirke av MT slik intervensjonen ble levert i våre studier.

**Praktiske implikasjoner:** Denne forskningen er viktig fordi MT intervensjoner kan være et nyttig verktøy for å beskytte mot tretthet og utmattelse under forlengede perioder med høy belastning. Funnene støtter visjonen om at MT kan være et lovende verktøy for å øke motstandskraften også til høyprestasjonsgrupper. Samtidig viste det seg at MT programmene i

våre studier ikke forbedret inhibisjon elementet av vårt overordnede kontroll system, slik det ble målt i disse studiene. Metodisk viser denne forskningen viktigheten av å bruke multifaktorielle mål på mindfulness og at computerbaserte tester kan være enkle og brukbare markører på inhibisjon i elitegrupper. Det er fortsatt behov for randomiserte kontrollerte studier (RCTs) med aktive kontroll grupper for å undersøke effektene av MT i høyprestasjonsmiljøer. Det er også behov for kvalitative studier for å undersøke mekanismene som ligger bak å være, og å bli, mer mindful i slike miljøer.



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## List of papers

- Paper 1: Meland, A., Fonne, V., Wagstaff, A., & Pensgaard, A. M. (2015). Mindfulness-based mental training in a high-performance combat aviation population: A one-year intervention study and two-year follow-up. *The International Journal of Aviation Psychology*, 25, 48-61.
- Paper 2: Ishimatsu, K., Meland, A., Hansen, T. A., Kasin, J. I., & Wagstaff, A. S. (2016). Action slips during whole-body vibration. *Applied Ergonomics*, 55, 241-247.
- Paper 3: Meland, A., Ishimatsu, K., Pensgaard, A. M., Wagstaff, A., Fonne, V., Garde, A. H., & Harris, A. (2016). Impact of mindfulness training on physiological measures of stress and objective measures of attention control in a military helicopter unit. *The International Journal of Aviation Psychology*, 25, 191-208.
- Paper 4: Meland, A., Høgmø, P. M., Ishimatsu, K., & Pensgaard, A. M. Inhibitory control is differentially associated with mindfulness facets in a high performance cohort. *Mindfulness*, (submitted).

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## Abbreviations

- ACT – Attentional Capture Test
- ANT – Attentional Network Test
- CAR – Cortisol Awakening Response
- EEG – Electroencephalogram
- EFs – Executive Functions
- FFMQ – Five Facet Mindfulness Questionnaire
- HSCL – Hopkins Symptom Checklist
- MBCT – Mindfulness Based Cognitive Therapy
- MBSR – Mindfulness Based Stress Reduction
- MT – Mindfulness Training
- NASA-TLX – NASA Task Load Index
- NMSQ-24 – Norwegian Mental Skills Questionnaire for Athletes
- NoRAF – Norwegian Royal Air-Force
- PROE – Positive Response Outcome Expectancies
- RCT – Randomized Controlled Trials
- SART – Sustained Attention to Response Task
- SAS – Sport and Anxiety Scale
- TFTs – Traditional Formatted Tasks
- WBV – Whole Body Vibration

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## Introduction

Failing to identify important changes or a lack of flexible responding in dynamic and complex environments may have large consequences on the outcome. Optimal performance under these circumstances depends on high quality action control and the ability to monitor present moment activity without much distortion and unnecessary stress-activation. A phenomenon and method currently drawing a substantial amount of interest worldwide, that could be useful in this respect, is mindfulness (Ricard, Lutz, & Davidson, 2014). The usefulness of this method may generalise across high performance environments such as elite athletes, aviators, first responders, and military personnel. For example, neuropsychological parallels have been drawn between successful performance in a combat scenario and expert performance at the highest level in sports (Walsh, 2014). Despite their differences, the commonalities in environmental characteristics between these elite groups seem intuitive. The ability to remain composed and focused during high intensity situations, also under non-optimal conditions is one important common characteristic. As attrition and fatigue can impact performance in negative ways, minimising unnecessary stress activation is another.

Due to these shared characteristics, collaborative initiatives between sports and the military have also been made within the psychology field (Goodwin, 2008; DeWiggins, Hite, & Alston, 2010). This thesis is an example of this, and is a joint venture between the Norwegian Armed Forces Institute of Aviation Medicine, Norwegian School of Sport Sciences and Norwegian Olympic Training Centre (Olympiatoppen). It was in the interest of both sports- and military-psychology to investigate the applicability and effects of mindfulness training (MT) in high performance groups operating in extreme environments. The aim was to increase the understanding of being mindful and applying MT as a means for

stress-reduction and improved attention- and action-control in high-performance cohorts exposed to extreme environments.

An extreme environment has been defined as an external context that exposes individuals to demanding psychological and/or physical conditions, which may have profound effects on cognitive and behavioural performance (Paulus et al., 2012). Elite athletes, aviators, military personnel and other first responders are groups who are exposed to a particular type of extreme environment, one that is characterised by complexity, uncertainty and rapid change. Successful performance in these contexts places even greater demands on quick and accurate information acquisition, followed by flexible and accurate action execution. As a consequence, much of the behaviour has to be automatized through extensive task training. However, complex and unforeseen situations cannot be processed solely on the basis of fast associations and easily applicable procedures. Sometimes a situation may require a quick stop or change in a planned and automatized response chain. Furthermore, it is not merely enough to know that stopping is required; experts must also have the capacity to carry out the stopping action. However, stopping or changing default behaviour is difficult, especially if time is short, actions are automatized and the stimuli signalling a change cannot be anticipated. It could be an unexpected move by an opposing player in soccer, a friendly soldier appearing among foes, or a sudden change in the attentional field of a pilot. This mirrors a fundamental distinguishing feature between experts and novices. Experts have the adeptness at ‘knowing’ what to do, but they also have the capacity and ability to actually ‘do it’ (Allard & Starkes, 1991).

An additional challenge is that suddenly appearing salient cues can be relevant to the observer in some situations, but irrelevant in others. Therefore, an important part of expertise in unpredictable environments where the appearance of stimuli cannot be anticipated is the ability to monitor a situation for relevant stimuli, without over-processing irrelevant salient

stimuli. Being momentarily captured by salient stimuli or stopping routine action may not pose a problem in daily life situations, when we have the time to take in the whole situation, and can reflect on the best action. However, for the elite groups in question they cannot always afford the luxury of taking this time. Competitive demands and the need for mission completion means the operational tempo must be kept high and often leaves them with less time to absorb the whole situation or slow down actions to prevent mistakes.

The ability to economise mental resources and avoid unnecessary stress-activation is a related aspect of concern to high performance environments. This has become even more crucial as the interval between deployments is reduced in the military, due to international instability and rationalisation (Tanielian & Jaycox, 2008). Likewise, with an increased focus on commercial profit in sports, there is a trend to increase the number of competitions. For example, in Norway soccer-games are now played all year round instead of being restricted to a restricted season (NFF, 2016). Consequently, as the need for competence is not reduced, athletes and soldiers have to endure longer work and training hours without compromising quality.

Before we unravel possible mechanisms behind any effects of mindfulness on attention- and action-control and stress-reduction, let us take a closer look at the mindfulness concept.

### **Mindfulness**

The concept of mindfulness stems from Buddhist and meditative traditions and is commonly defined as ‘paying attention in a particular way, on purpose, in the present moment, and nonjudgmentally’ (Kabat-Zinn, 1994, page 4). Mindfulness is also described as a ‘mental mode characterized by attention to present-moment experience without judgement, elaboration, or emotional reactivity’ (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010, p. 54). Mindful individuals are described as having a heightened contact with moment-to-moment

experience and all stimuli, experiencing few distortions and less reactivity related to emotional valence (Bishop et al., 2004; Brown, Ryan, & Creswell, 2007). Although the term mindfulness is used in different ways, most theories acknowledge that being mindful can be an inherent trait, but also a trainable skill. In broad terms MT refers to all techniques and activities with the aim of heightening the level of mindfulness (Tang, Holzel, & Posner, 2015).

Contemporary mindfulness in the West started with the Mindfulness Based Stress Reduction Program (MBSR; Kabat-Zinn, 1994), and gained momentum with the Mindfulness Based Cognitive Therapy programme (MBCT; Segal, Wittmann, & Teasdale, 2002). The MBSR started as a clinical intervention for chronic pain, while the MBCT aimed at preventing recurring depression. Today these programmes have a much wider application and are used to target a wide range of problems and challenges. Mindfulness has also become a popular tool for performance enhancement for elite groups. For example, there are now MT-programmes specifically tailored for both soldiers (Jha et al., 2010) and athletes (Birrer & Morgan, 2010).

Depending on age, the type of group and time available, the content and length of exercises and overall programme varies. Nonetheless, the main characteristics and principles are retained across most programmes building on the MBSR and MBCT programmes. Characteristically they contain a mix of theoretical lectures and meditation exercises done individually, in a group-setting and/or as homework. The exercises are done sitting or lying down, following simple instructions. Most programmes emphasise concentration exercises on how to stabilise and focus attention on present moment experience. Every time they notice that their attention has wandered, they are encouraged to gently return to the present moment. Participants are encouraged to adopt a state of restful alertness to present moment experience, stressful or not, making no effort to control thoughts or feelings that may emerge. More broadly, when engaging in MT one trains specific attention-control skills, while remaining in

an open and non-judgemental stance to experience (Bishop et al., 2004). A detailed description of the interventions and the instructions given to the participants in the current research are provided in the methods section.

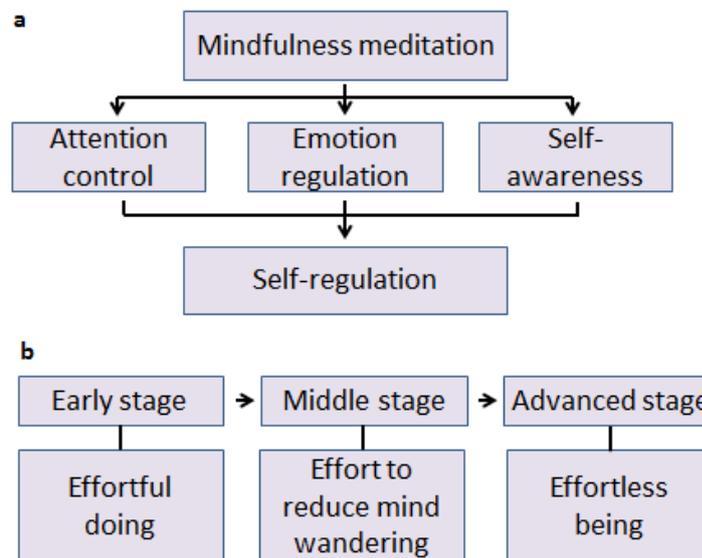
Mindfulness is multifaceted and several multidimensional models have been outlined. Bishop and colleagues (2004) proposed a two component model suggesting that being mindful involves increased self-regulation and monitoring. Self-regulation refers to the capacity to actively suppress, or return from distractors in order to remain attentive to immediate experience. Monitoring involves approaching inner and outer experiences with openness, regardless of valence and desirability (Bishop et al., 2004). Baer and colleagues (2006) proposed a five-component model of mindfulness including: *Observation* (i.e., noticing or attending to internal and external experiences), *description* (i.e., labelling internal and external experiences), *acting with awareness* (i.e., attending to current activities), *non-judgement* (i.e., taking a non-evaluative stance towards inner experience), and *non-reaction* (i.e., allowing thoughts and feelings to come and go without overreacting or getting caught up in them) (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006).

Due to the multidimensionality of mindfulness and the rich and eventful MT-programmes, it is associated with a range of benefits and numerous active ingredients. The authors of a recent review (Gu, Strauss, Bond, & Cavanagh, 2015) provided a list of mechanisms that could be considered when explaining the impact MT may have on individuals:

...repetitive negative thinking, AMS [autobiographical memory specificity], re-perceiving, reactivity, nonattachment, nonaversion, self-awareness, self-regulation, self-transcendence, psychological flexibility, clarification of inner values, exposure, attentional control and regulation, body awareness, mind-body and integrated functioning, emotion regulation, self-compassion, compassion, insight, acceptance, relaxation and ethical practices. (p. 3)

The vast number of proposed mechanisms and the lack of an encompassing theoretical framework to explain why MT is helpful is a challenge to the field. Most importantly, it

makes it difficult to design targeted interventions that maximise the benefits and limit the costs. In addition, there are also concerns about the growing development of brief and superficial contemporary programmes, because they may be very different from comprehensive traditional programmes (Rapgay & Bystrisky, 2009). Nonetheless, there is some consensus about some fundamental mechanisms behind the process of becoming more mindful. In a recent review of the neuropsychological literature on mindfulness, the authors attempted to clarify this issue by producing a comprehensive mindfulness model (Tang et al., 2015). Their model is reprinted with permission and illustrated in figure 1.



*Figure 1.* a) The mechanisms of change in mindfulness-meditation. b) How different stages of practice involve different amounts of effort (Tang et al., 2015).

The model illustrates that being mindful and engaging in MT are associated with heightened self-regulation through improvement in attention control, emotion regulation and self-awareness. Improved attention control refers to the ability to let attention rest in the ‘here and now’, flexibly moving it, and inhibition of excess thought (Bishop et al., 2004). Improved emotion-regulation refers to the ability to openly experience inner events leading to

adaptation, and consolidation. Improved self-awareness refers to a combination of enhanced body awareness and diminished self-referential processing (Hölzel et al., 2011). Another important finding of their review was that there was some consensus in the literature suggesting that MT reduces the amount of mental effort needed to be attuned to the present moment. This is specifically illustrated in part b of figure 1. In elite groups where the performance is already optimal, increased economisation, or efficiency of limited attentional resources may be an important outcome of MT. This would be particularly so for individuals who have to remain attentive for longer periods of time.

### **The Use of MT in High-Performance Environments**

The use of mindfulness in sports and the military is becoming popular, despite a scarcity of research on the effects of mindfulness in elite cohorts. Preliminary evidence involving athletes has shown that being naturally mindful or engaging in MT is beneficially associated with key variables, such as sport performance, task-orientation, flow, satisfaction, well-being, stress, anxiety, burnout, worries, and maladaptive perfectionism (for reviews see Birrer, Rôthlin, & Morgan, 2012; Sappington & Longshore, 2015; Zhang, Chung, & Si, 2015). Although promising, this research suffers from an exclusive use of subjective outcome measures and small study samples, where few of the studies included athletes competing at the highest level. An important critique of the literature is also that there are signs of a positive publication bias, as most studies are designed to confirm the benefits associated with mindfulness, leaving potential costs of mindfulness largely unknown. This is particularly problematic, because mindfulness have indeed been associated with potential costs, such as hypersensitivity in clinical groups (Segal et al., 2002; Wells, 2009). On the same note, higher levels of mindfulness have been associated with lower implicit sequence learning in the normal population (Stillman, Feldman, Wambach, Howard, & Howard, 2014), and a five week MT-programme increased the recognition of true memories, but also provoked more

false memories (Rosenstreich, 2015). Whether there are significant costs of being naturally mindful or from engaging in MT when belonging to a high-performance group remains an unanswered question.

Thus, in order to make informed decisions regarding mindfulness at the highest level, coaches and athletes need to know more about the benefits and potential costs of being mindful and the training. This involves insight into the exact association between mindfulness facets and variables that may impact sport performance. Two areas that have been found to be closely associated with mindfulness and could prove important for high-performance environments are stress-reduction and the inhibition element of executive control.

### **Mindfulness and Stress-Reduction**

Research on mindfulness indicates that individuals with naturally higher levels of mindfulness report feeling less stressed, anxious, and depressed, and more content, vital, and satisfied with life, in comparison with individuals who score lower on mindfulness measures (Greeson, 2009). In general, the beneficial link between MT and stress-reduction in healthy adults is well-established (Chiesa & Serretti, 2009; Conley, Durlak, & Dickson, 2013; Ditto, Eclache, & Goldman, 2006; Khoury, Sharma, Rush, & Fournier, 2015; Regehr, Glancy, & Pitts, 2013; Sedlmeier et al., 2012; Tang et al., 2015; Tang et al., 2009; Virgili, 2013). However, the research on elite cohorts is lacking, and despite mounting evidence of the stress-reducing effects of MT, there are also some mixed findings. For example, a recent review including studies with active control conditions showed no stress-reducing effects of MT, but small to moderate effect sizes were found for anxiety, depression and pain (Goyal et al., 2014). In another review, only four out of eight studies found beneficial changes in cortisol-levels after engaging in MT-interventions (Matousek, Dobkin, & Pruessner, 2010).

Some have argued that MT has a stress-buffering effect (Jha et al., 2010), meaning that one would only expect stress-reducing effects in cohorts already experiencing stress or who

are being exposed to stressful environments. Indeed, the most consistent stress-reducing effects of MT have been found in highly stressed community workers (Nyklicèk, Mommersteeg, Van Beugen, Ramakers, & Van Boxtel, 2013), nurses (Klatt, Steinberg, & Duchemin, 2015), and patient populations exposed to prolonged stressors e.g., patients with HIV, psoriasis, pain, or chronic inflammation (Cohen, Janicki-Deverts, & Miller, 2007).

Studies have found that mindfulness promotes adaptive patterns of affective experiences by inhibiting maladaptive coping styles (Keng & Tong, 2016). Others argue that it is the broadening of perspective on experience that is responsible for the beneficial effects of mindfulness on well-being because it opens up for constructive thoughts, leading to a positive-spiralling-effect (Garland, Kiken, Furot, Palsson, & Gaylord, 2016). Another possibility is that being mindful involves having more positive response outcome expectancies (PROE), which has been linked to stress-reduction in all species (Eriksen & Ursin, 2002; Ursin & Eriksen, 2004).

There may be several mechanisms linking mindfulness to stress-reduction, but changes in attention- and emotion-regulation strategies seem to be of particular importance (Tang et al., 2015). Emotion regulation refers to strategies that can influence which emotions arise, when and how long they occur, and how these emotions are experienced and expressed (Gross, 2002). Emotion regulation can happen in several overlapping ways, and can be categorised into at least two neurologically separable strategies: top-down or bottom-up. The former is thought to manipulate the input to the emotion-generative systems such as the amygdala, through prefrontal brain regions (Quirk & Beer, 2006). An example of a top-down strategy is cognitive reappraisal, where emotions are regulated by actively reinterpreting stimuli to modify their emotional impact (Gross, 2002). The latter strategy has been termed bottom-up because it can involve a direct modulation of emotion-generative brain regions,

without necessarily involving an active recruitment of higher order brain regions (Chiesa, Serretti, & Jakobsen, 2013).

A pure bottom-up strategy would be exposure to stressful stimuli, which over time could promote adaptation and lowering of the activation response to emotional stimuli (Hölzel et al., 2011). MT could be considered an example of the latter as the way to regulate one's emotions in MT is to openly direct attention to emotionally salient stimuli without actively trying to change anything (Goldin & Gross, 2010). Over time, this perceptual openness is thought to facilitate a non-evaluative contact with moment-to-moment experience resulting in an awareness of stimuli with less reactivity related to emotional valence (Brown et al., 2007). This has been confirmed in neurological research suggesting that the stress reducing effects of MT are related to a combination of adaptation, consolidation and attribution processes (Hölzel et al., 2011). Adaptation effects may be particularly important in high performance environments because after successful adaptation, it takes no additional effort or processing capacity unlike active reappraisal strategies.

Adaptation effects of mindful awareness during stressful situations have been found, suggesting that attending to interoceptive afferents results in greater adaptation. For example, one study demonstrated that, compared to their less-mindful counterparts, mindful adults presented with arousing unpleasant images, revealed brain states associated with a lower stress-response, but also higher sensitivity to the images (Brown, Goodman, & Inzlicht, 2012). This suggests that being mindful involves increased resilience towards the negative effects of stimuli with emotional valence, without reductions in present centred awareness. This may be highly adaptive in elite groups exposed to extreme environments, where relevant cues may also be of particular emotional potential. A fMRI study of seven elite BMX cyclists revealed that eight weeks of MT increased their attention to bodily signals and greater neural processing during recovery from interoceptive perturbations (Haase et al., 2015). This study

illustrates that MT can help experts turn towards inner potential stressful stimuli instead of using distraction strategies.

Clearly MT should not be confused with reappraisal strategies, or any method that prescribes manipulating the content of thoughts or feelings. Nevertheless, many of the effects of being mindful have been linked to changes in top-down cognitive processing (Segal et al., 2002). For example, observing a thought such as ‘I cannot stand this’ without judgement or reaction may lead to a belief that it is ‘just a thought’ not worth an expanded activation response. It has been further suggested that such pauses in the flow of thoughts give an individual the possibility to choose how to respond to the inner events in helpful and non-reactive ways (Goldin & Gross, 2010). In addition, a shift from a daily mode of automatic mind-wandering to restful present moment awareness may be stress-reducing in itself, because it involves spending less resources refocusing and/or ruminating about past and future events (Roemer et al., 2009; Segal et al., 2002).

Adaptation and bottom-up emotion regulation strategies may be a beneficial way to improve stress-resilience in high performance cohorts. However, it is also probably the one that takes the largest investment. Studies have found that habituation and adaptation effects of MT may require long-term practice (Chiesa et al., 2013). Finding the time to do the prescribed training, may therefore pose a particular problem to elite cohorts with strict schedules. Another problem is that the strategy of attending to potentially stressful internal events with greater openness may feel counterintuitive to some. This could be especially so for those who have previously relied primarily on positive thinking and top-down governed reappraisal strategies. From reviewing the literature, the popularity of mindfulness in performance environments seems to be tied to its potential for stress-reduction (Birrer et al., 2012; Fornette et al., 2012; Jha et al., 2010). The field is in its infancy and there may be several other areas which being mindful and engaging in MT may be important to high performers.

A common objective of training in sports and for those operating in high risk environments is to achieve a high degree of automaticity. However, a total reliance on routine execution seems insufficient to reach the highest level, because distractions and unexpected events always occur in real life. Recent research suggests that even for elite athletes in sports performed in stable environments such as golf and ice-skating there is a need to flexibly switch between automatic and deliberate action execution throughout a competition (Bernier, Trottier, Thienot, & Fournier, 2016). We can assume that the need for flexibility in higher order control is even greater in sports performed in unstable environments. An area that may be particularly important to peak performance in these contexts to achieve this flexibility is therefore inhibitory control – the most fundamental of our higher order executive control functions (EFs).

### **Inhibition**

Based on rigorous perceptual and cognitive testing, Miyake et al. (2000) suggests that our EFs consist of three distinct functions: a) hold information in the mind, mentally manipulate this information, and act on the basis of it (*updating*), b) quickly and flexibly adapt behaviour to changing conditions situations (*shifting*), c) exercise self-control by resisting inappropriate behaviours and responding appropriately (*inhibition*).

EFs play a fundamental role in the dynamics of human cognition and action, particularly during time constraints and in situations that require more than routine execution of automatic and overlearned schemata. Thus, EFs clearly play a crucial role in high performance environments like in open sports (Voss, Kramer, Basak, Prakash, & Roberts, 2010). Still the research within this domain in sport psychology has mainly focused on areas like visual anticipation, pattern recognition, and strategic decision-making, using sport-specific tests (for reviews, see Memmert, 2011; Casanova, Oliveira, Williams, & Garganta, 2009; Mann, Williams, Ward, & Janelle, 2007). This strong tradition of maximising face

validity has precluded standardised tests of general higher-order EFs. This may be an important omission, as ‘game intelligence’ is assumed to be important in strategic sports like soccer (Reilly, Richardson, Stratton, & Williams, 2004), a concept that seems closely related to EFs. There is also research investigating the attentional foci of athletes during high stake natural performance situations, showing a great variability of attentional focus according to the changing nature of situational demands (Bernier, Codron, Thienot, & Fournier, 2011; Bernier et al., 2016). This research underscores the need for a flexible higher order control of attention and action also at the highest level of expertise. Furthermore, there is research suggesting that experts in different sports are able to transfer higher-order cognitive skills between sports that make them more successful in the new sport than novices (for a review, see Williams, Ford, Eccles, & Ward, 2011).

One of a few published studies on EFs in sports showed that young soccer players outperformed youths from a normal-population cohort on a general test of EF, and also that high-division players outperformed low-division players (Vestberg, Gustafson, Maurex, Ingvar, & Petrovic, 2012). This study used a more global test of EFs, and could not pinpoint which of the EFs were the most important. For the scope of the current thesis, we therefore chose to focus on the inhibition element of EF. Furthermore, current evidence suggests that inhibition is the most fundamental of the EFs (Miyake & Friedman, 2012).

There are several sub-categories of inhibition, in which all involve a certain degree of higher order inhibition. We chose to focus on two sub-categories of inhibition, because of their potential relevance to the high-performance groups in question:

1. *Inhibition of task-irrelevant stimulus processing* (i.e. stimulus driven attentional capture) involves increased sensitivity to relevant stimuli and reduced processing of irrelevant salient stimuli (Theeuwes, 2014).

2. *Response inhibition* involves reduction in the negative consequences of impulsiveness (Helton, 2009; Sakai, Uchiyama, Shin, Hayashi, & Sadato, 2013).

**The attentional capture phenomenon** occurs when highly salient stimuli, relevant or not, are given priority by our nervous system in a bottom-up manner (Theeuwes, 2014). Most of the time we can guide our attention at will so it is consistent with our goals and intentions. However, there are also situations where we have our full attention directed to the task, but cannot help but be distracted by our environment. This happens all the time in our daily life, as we have all experienced that our attention has automatically been hijacked by a thought or someone passing in our field of sight. This phenomenon helps us to notice a sudden appearance of an unexpected pedestrian/object while driving. However, a lack of inhibition may also result in over-processing of salient but irrelevant stimuli and therefore reduced sensitivity to target stimuli (Theeuwes, Kramer, & Kingstone, 2004). While the stimulus driven attentional capture phenomenon easily be intensified, it cannot be completely avoided. It has been found to be effectively curbed by narrowing our attentional focus (Theeuwes, 2014). However, this is not an option in critical situations where the occurrence of target stimuli cannot be anticipated, because it requires that one keep a wide and dispersed focus to maintain situational awareness.

**Response inhibition** refers to stopping motor action that is no longer required or inappropriate (Verbruggen & Logan, 2008). Experts in many fields rely heavily on automatic behaviour and overlearned schemata. However, the ability to stop, delay or change a planned response chain is sometimes equally important, but is sometimes difficult to carry out during automatic and repetitive actions. Most people are familiar with how challenging this may be. For example, we may unintentionally have thrown the vegetables in the garbage instead of the

peelings, or failed to stop a default ticking of 'yes' boxes in a questionnaire when a question suddenly requires a 'no' answer. The natural strategy in times of uncertainty is to slow down in order to reduce the chance of mistakes, but this is not always an option in critical situations. Moreover, a lack of response inhibition is only a problem when the need for a stop action cannot be anticipated or properly prepared in advance - in other words, when the need to 'stop' is signalled by rare and unexpected stimuli, which is often the case for the groups in question. As mentioned previously it could be an unexpected move by an opposing player in soccer, a friendly soldier appearing among foes, or a sudden change in the attentional field of a pilot.

There will always be a delay between when a signal is presented until you manage to execute the stopping action, but this delay should be kept to a minimum. This could be achieved by keeping the interference of salient distractors low and improving action control through proactive and/or reactive stopping processes. Proactive stopping functions as a brake to responding when future events are uncertain and enables slow but accurate response (Aron, 2011; Sakai et al., 2013). Reactive stopping involves a lessening of the reaction to errors (Helton, 2009; Sakai et al., 2013).

In almost all cases stimulus-driven attentional captures and action slips due to a lack of inhibition are short-lived and cause no more than momentary embarrassment or annoyance. However, these phenomena may have larger consequences in high performance environments. In fact, a number of problems and accidents in high risk environments have been related to short lived and transient failures in input and/or output processes (Reason, 1990; Reason & Mycielska, 1982). For example, it is estimated that 75% of pilot errors result from failures in input processes such as poor perceptual encoding (Stanton, Chambers, & Piggott, 2001), which may lead to poor decision-making. Despite a lack of research, these aspects of inhibition are currently receiving a growing interest in the military, as distractor interference and failures in the ability to stop an automated behaviour have been associated with

impulsiveness, collateral damage and friendly fire accidents during operations (Wilson, Head, de Joux, Finkbeiner, & Helton, 2015). There is a need for efficient interventions because, despite technological advancements, collateral damage is still a problem and friendly fire incidents have steadily increased since the Second World War and are now estimated to account for 10-24% of allied-force casualties (Gadsen, Krause, Dixson, & Lewis, 2008). Although trivial to most people, sufficient inhibitory control at the level of response inhibition and stimulus-driven attentional capture is clearly important to individuals operating in extreme environments.

### **Mindfulness and Inhibition**

There is now extensive research suggesting that, by being mindful, you are less distracted, more sensitive to goal-relevant aspects, and can execute behaviour in a controlled and effortless manner (Tang et al., 2015). It has been suggested that these improvements in self-regulation are closely linked to improvements in inhibitory control (Bishop et al., 2004). A recent review of the literature showed that inhibition is the only EF that was consistently associated with mindfulness (Gallant, 2016). However, this has not been thoroughly investigated in high performance cohorts, at least not at the level of automatic motor action and stimulus-driven attentional capture. One study of military recruits found that mindfulness mediated the relationship between self-reported worry and impulsivity (Mantzios, 2014). Due to the cross-sectional nature of this study and exclusive use of self-report measures one cannot conclude that by increasing mindfulness impulsivity is thereby reduced. Recently, two controlled studies tested MT on active-duty U.S. Army male soldiers prior to deployment to Afghanistan (Jha et al., 2015; Jha, Morrison, Parker, & Stanley, 2016). Although the participants may not be categorised as elite, these studies found that, compared to active controls, eight hour MT interventions effectively prevented decrements in inhibitory functioning as measured by the Sustained Attention to Respond Task (SART). This is the

same test of response inhibition used in the current thesis, although they used an extended version.

Regarding mechanisms, the beneficial link between mindfulness and inhibition has been associated with reductions in the propensity for mind-wandering (Cheyne, Carriere, & Smilek, 2006), but also to improvements in higher order control mechanisms (Teper, Segal, & Inzlicht, 2013). The link to mind-wandering seems intuitive, because it directly relates to loss of sustained attention. However, the link to higher order control mechanisms is not straightforward.

Central to most models of cognitive control is the suggestion that ongoing performance is continually monitored for events that threaten successful goal attainment, such as conflict, errors, or negative feedback (Botvinick, Braver, Barch, Carter, & Cohen, 2001). It is proposed that the affective responses tied to these events signal the recruitment of higher-order control systems (Weinberg, Riesel, & Hajcak, 2012). The link to mindfulness is that the increased awareness and sensitivity to ‘all stimuli’ found in mindful individuals (Farb, Segal, & Anderson, 2013) transfers to increased recruitment of higher-order control mechanisms, including inhibition. With regards to improvements in distractor-interference, studies have shown that strengthening target sensitivity would probably be a more efficient strategy than trying to shut out the distractors (Theeuwes et al., 2004). This is the exact strategy conveyed in MT, where you are instructed to bring attention back to the present moment or a target object (e.g., breath or body part) when focus is lost.

Moreover MT requires the control of attentional focus, the inhibition of elaborative thought and actions, and reorientation or disengagement of attention. It is believed that the repetition of these activities over time leads to changes in brain structure in mindfulness practitioners (Fox et al., 2014). Being mindful or engaging in MT would particularly impact the activity and integration of three intrinsic brain networks important for

the regulation of attention and arousal: the default network, the executive network and the salience network. The neurological mechanisms on the level of neural networks is beyond the scope of this thesis (for a more thorough coverage of this topic, see Mooneyham, Mrazek, Mrazek, & Schooler, 2016).

### **Purpose of the Four Studies**

Due to competition, mission effectiveness and technological developments, both elite sports and military aviation are continuously trying to find ways to optimise performance and reduce the negative consequences of stress and high workloads. Until today, sport psychology has frequently relied upon cognitive reappraisal methods and relaxation techniques to regulate emotions and arousal, but in the last decade acceptance-based approaches have become increasingly popular (Bernier et al., 2009; Birrer & Morgan, 2010). There is a sound rationale for claiming that MT is a psychological intervention that can reduce systemic arousal without compromising perceptual-cognitive functioning, but again this has not been thoroughly investigated in high performance cohorts. Addressing this gap in the literature is important in order to make informed decisions about the costs and benefits of being mindful and future use of MT in high performance environments.

### **Aims and research questions**

The overall aim of this thesis was therefore to contribute to an increased understanding of the consequences of engaging in MT when you are already a high performing individual operating in a particular type of extreme environment. We wanted to highlight aspects related to feasibility of the MT program, stress-reduction and inhibitory control, using a mix of objective and self-report measures. Four studies were undertaken, resulting in four corresponding papers, where no paper draws on the data from more than one study.

**Paper 1.** *Research question: Is a one-year MT program a feasible method to increase self-reported mindfulness, attention regulation, arousal regulation and performance-related anxiety in a high-performance environment?* We expected that the participants would adhere to the program, but also a great variety in the feedback on the program. We hypothesized that, among those who adhered to the prescribed training, the MT would lead to an increase in self-rated levels of mindfulness, and attention- and arousal-regulation. We did not expect to see reductions in already low levels of performance-related anxiety. Further, we expected to see some long-term effects of this comprehensive intervention.

**Paper 2.** *Research question: Is the Sustained Attention to Respond task (SART) a useful and sensitive marker of changes in response inhibition in a high performance cohort exposed to an environmental stressor (i.e., whole body vibration (WBV))?* We hypothesised that WBV would increase the probability of failure in sustained attention and response inhibition, and that this was more likely during exposure to WBV. Therefore, we expected to find a higher frequency of errors of commission (i.e., action slips), errors of omission (i.e., lapses) and faster response times during exposure to WBV than when WBV was absent.

**Paper 3.** *Research question: Is a 4-month MT an effective method of stress-reduction and inhibition in a high performance cohort exposed to a prolonged period of high workload, using objective and subjective measures?* We hypothesized that the MT group would have increased self-perceived mindfulness. Further, we hypothesised that the restorative effects of MT would produce general increases in wake-up values of saliva cortisol in the MT group while evening values would remain low. We also expected to see a stronger rise in saliva cortisol levels in the 30 minutes after wake-up. Based on the proposed change in attentional strategy, we expected that the MT group would commit fewer errors on the SART and increased sensitivity to a target on the attentional capture task (ACT). We also expected that

the MT group would find the SART less demanding to perform after the intervention, compared to the control group.

**Paper 4**<sup>1</sup>. *Research question: What is the relationship between trait mindfulness, and objective measures of response inhibition and stimulus-driven attentional capture prior to exposure to MT?* We hypothesised that all facets of mindfulness would be associated with improved scores on the tests of inhibitory functioning, both at the level of response inhibition (i.e. better SART scores) and inhibition of task-irrelevant stimuli processing (i.e. better ACT scores).

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<sup>1</sup> Initially, the aim of this study was to evaluate the effect of the same intervention as in study 3. Unfortunately, we were not able to collect post-intervention data in this group and this aim was abandoned. A year later, we decided to analyze the pre-data with the aim of investigating a potential association between trait mindfulness and performance on our computerized tests of inhibitory control.

## Methods

### Research designs and statistics of studies

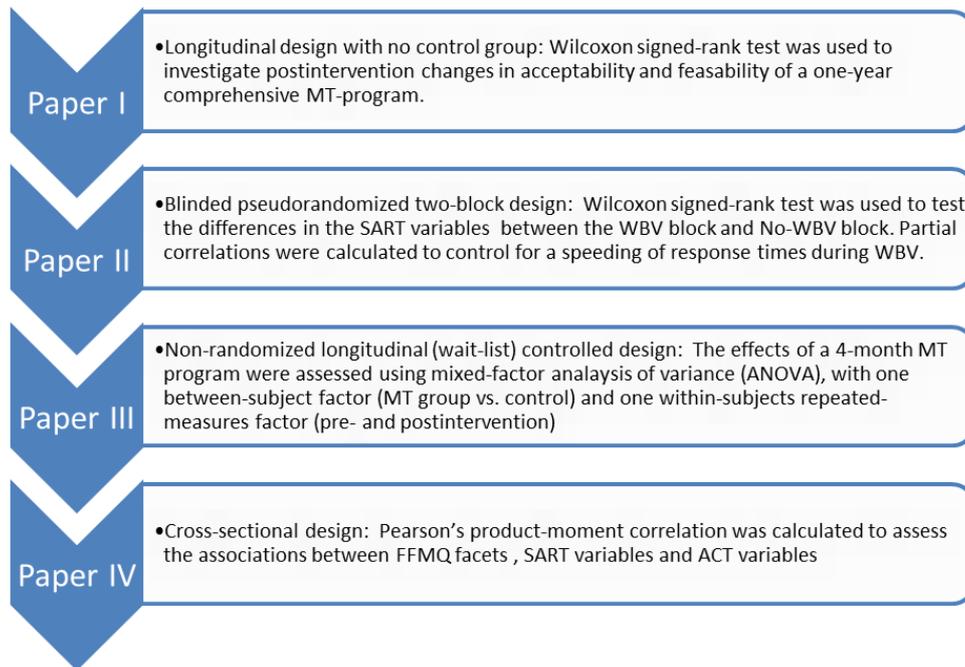


Figure 2. Overall research designs for studies within the current thesis

Statistics in all studies were calculated using SPSS (IBM Corporation, Armonk, NY). All papers included demographics, means and standard deviations. Independent-sample *t*-tests were used to assess baseline group differences in study 1 and 3. To confirm that our shortened version of the ACT worked as intended in study 3 and 4, we used a one-way ANOVA to investigate differences in RTs between five measured conditions (see measurement section). The significance threshold was set at  $p < .05$  for all analyses.

## Participants

Access to high performance cohorts for research purposes is challenging. We recruited participants coming from military aviation, elite orienteering, and professional soccer. Access to these elite groups was provided through the Norwegian Olympic Training Centre (Olympiatoppen) and the Flight Safety Department of the NoRAF. Although diverse, the selection of participants was reasonably representative of high performing individuals dealing with complex and unforeseen situations in rapidly changing environments.

**Paper 1.** Participants ( $n = 21$ ) from a high performance combat aircraft unit were recruited based on internal reports of attrition and fatigue in this type of environment. Mean age was 33 years (range = 22–50 years). One participant was female, 67% had one child or more, and 76% were either married or living with a partner who was employed part or full time. Mean work experience in combat aviation was 6 years (range = 1–13 years).

**Paper 2.** We gained access to 19 elite runners in orienteering competing at a national level. Orienteering is a highly cognitive sport and these athletes were highly trained in carrying out information processing tasks under environmental stress, therefore reducing the effects of discomfort. The group of participants consisted of 10 females and 9 males, mean age = 23 years,  $SD = 4$ , range = 21–37. All participants had normal or corrected-to-normal vision.

**Paper 3.** We wanted to test the stress-buffering effects of MT and needed a group that was exposed to considerable workload. We therefore capitalised on the rare opportunity afforded by access to two helicopter units (males only) during a high-workload interval (i.e., during deployment). One group ( $n = 25$ ) received a 4-month MT-programme (mean age = 35 years,  $SD = 13$ , range = 18–62) and the other group ( $n = 15$ ), served as a wait list control (mean age = 40 years,  $SD = 10$ , range 26–56).

**Paper 4.** Forty-two male players from two Norwegian professional men’s soccer clubs were recruited through the head coaches (mean age = 27 years, SD = 5, range = 19-38). We chose soccer, because this is a cognitively demanding sport where attention- and action-control seems critical (Coutts, 2016).

**Overview of intervention studies**

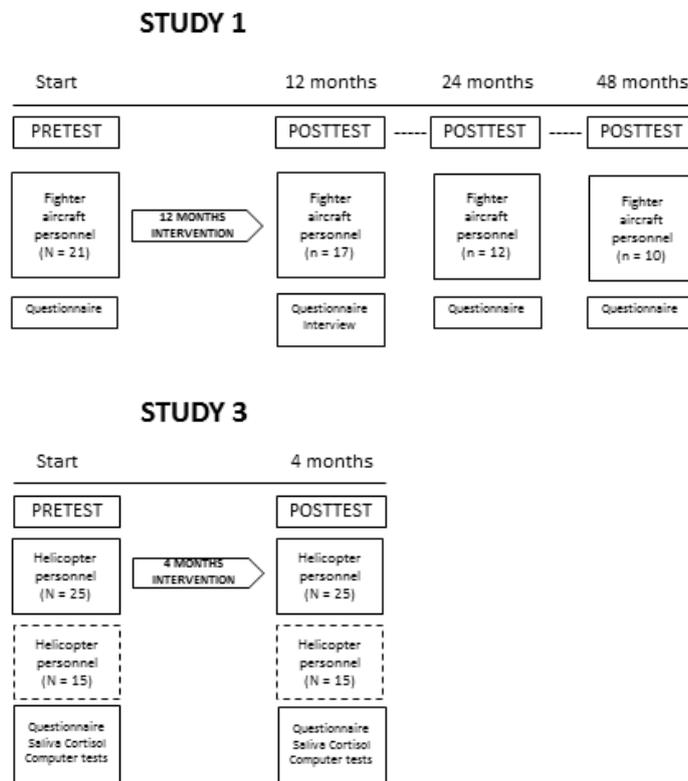


Figure 3. Overview of the timing and flow in the intervention studies (paper 1 and 3).

### **The Interventions**

Two MT interventions were designed, following the guidelines of the MBSR (Kabat-Zinn, 1994) and the MBCT (Segal et al., 2002) with the basic structure of 25% theoretical lectures and 75% guided MT. Theoretical lectures discussed why and how MT could be helpful. Guided practice consisted of the three basic exercises used in the MBSR and MBCT programmes:

1. **Sitting meditation:** Sitting on a chair while practicing being present with one's breath and noticing thoughts, feelings, and bodily sensations.
2. **Body scan:** Lying down while practicing awareness of one part of the body at a time.
3. **Mindful movements:** Simple movements such as standing, sitting, or lying down to practice being present and paying attention to movements.

The duration of each exercise varied from 20 to 45 min. At plenary sessions, participants were invited to share experiences and problems from their personal practice in discussion groups with two to four participants. Each group then gave an informal summary presentation to the larger group.

The intervention started with a 10-hour introductory course to give participants an introduction to the practical and theoretical elements of MT so they could start their own practice immediately. 2.5 hours of plenary sessions were scheduled every third week for 12 months in the combat aircraft unit and weekly for four months in the helicopter unit. Participants were also offered a two-day retreat (three days for the combat aircraft cohort) towards the end of the intervention period to deepen their practice and understanding of mindfulness.

Participants received pre-recorded soundtracks with guided MT to personally practice outside of class for a minimum of 20 minutes three times per week. To increase the amount of MT, participants were encouraged to add mindfulness to everyday activities that they usually

did on 'autopilot', such as working out, talking, listening, eating, walking, and driving. To further stimulate integration of MT into daily life, the participants' respective partners were also offered the 10-hr introductory mindfulness course. To make MT more readily acceptable to the population, the intervention was carefully designed to fit a high-performance military environment, adopting some of the mental preparation activities used by elite athletes. I was myself one of the MT instructors. Since I am a military officer, one could assume I facilitated programme acceptance due to my knowledge of the military community and culture. MT instructors had a minimum of 10 years of meditative practice and were formally accredited mindfulness training instructors at the Scandinavian Centre for Awareness Training, Oslo, Norway.

Table 1.

*Overview of Theoretical Content of the 10 Hour Introductory Course***Day 1:**

<b>Lecture:</b>	<b>Content</b>
What is meditation?	Your experiences with meditation.
Sitting meditation	Learning to observe things as they are.
Today's society	Autopilot and how we relate to ourselves.
Stress	What is stress? How can mindfulness-training help?
Breathing anchor	Where and how to pay attention to our breath
Body scan	Flexible focus and how paying attention to our body may be helpful
Awareness	Being present, brain-waves and our experience of time.
Attention	Learning to control it starts with being aware of it.

**Day 2:**

<b>Lecture:</b>	<b>Content</b>
Yoga and walking meditation	Being mindful while moving.
Mindfulness in daily life	Stop, observe, accept, let go (S-O-A-L).
Motivation	Are you going to practice meditation in everyday life and how?
Q&R and evaluation	

Table 2.

*Overview of Practical and Theoretical Content of the Two Day Retreat***Day 1:**

<b>Lecture:</b>	<b>Content</b>
Introduction	<ul style="list-style-type: none"> <li>- Why investing time in this retreat?</li> <li>- The principles are the same - deepening the practice</li> <li>- Four themes: 1) calming the body, 2) mastering emotions, 3) knowing the mind, 4) knowing nature and its laws</li> <li>- Letting go of expectations</li> </ul>
1. Calming the body	<ul style="list-style-type: none"> <li>- Observing long breath</li> <li>- Observing short breath</li> <li>- Knowing all the “bodies”</li> <li>- Calming the breath</li> </ul>
2. Mastering emotions	<ul style="list-style-type: none"> <li>- Observing turbulent feelings</li> <li>- Observing calm feelings</li> <li>- Observing how feelings affect the mind</li> <li>- Calming the feelings</li> </ul>

**Day 2:**

<b>Lecture:</b>	<b>Content</b>
3. Knowing the mind	<ul style="list-style-type: none"> <li>- Observing the mind</li> <li>- Pleasing the mind</li> <li>- Concentrating the mind</li> <li>- Freeing the mind</li> </ul>
4. Knowing nature and its laws	<ul style="list-style-type: none"> <li>- All things change</li> <li>- Dissolving attachment</li> <li>- No attachment</li> <li>- Giving it all back</li> </ul>

**Day 3:**

The retreat lasted three days for the combat aircraft cohort in study 1. To deepen their practice and experience of the four themes, they spent the additional day in silence. The ‘silent- day’ involved spending 24 hours in silence, without speaking or communicating with each other, together as a group and alone.

Table 3.

*Overview of Theoretical Content of Plenary Sessions and Homework*

<b>Session</b>	<b>Theoretical content</b>	<b>Homework</b>
1	<i>Autopilot and the “breathing anchor”</i> <ul style="list-style-type: none"> <li>– We live a large part of our daily lives on autopilot.</li> <li>– The cost and benefits of operating on autopilot.</li> <li>– It starts with stopping and observing where we have our attention.</li> <li>– Anchoring our attention to the breath and the body.</li> <li>– The hallmarks of the breath.</li> <li>– Cultivating flexibility.</li> </ul>	Find activities you do on autopilot.
2	<i>Dealing with barriers</i> <ul style="list-style-type: none"> <li>– Experiencing things getting worse (i.e., stress and focus).</li> <li>– ‘Monkeymind’ (chain of thoughts).</li> <li>– Falling asleep is a problem.</li> <li>– Trouble finding the time to do the practice.</li> <li>– The training conditions are never perfect.</li> <li>– What to do when strong emotions show up during practice.</li> <li>– Creating a powerful implementation strategy.</li> </ul>	Add awareness to an activity you do on autopilot.  Whatever you do – try to do it 100%
3	<i>Body awareness</i> <ul style="list-style-type: none"> <li>– The problems with solving emotional problems intellectually.</li> <li>– The importance of body awareness for performance and health.</li> <li>– Body awareness – what is it, where does it come from and how can we use it?</li> </ul>	Experiment with slowing down during daily routines.
4	<i>Staying present</i> <ul style="list-style-type: none"> <li>– The importance of being here and now for peak performance.</li> <li>– Goalsetting and mindfulness – a contradiction?</li> <li>– The problem with wishing things was different.</li> <li>– Returning to the here and now - short circuits stressful past and future thoughts.</li> <li>– The importance of patience.</li> <li>– Beginner’s mind – how it can help you.</li> <li>– A ‘resting’ focus.</li> </ul>	Experiment with not using the soundtracks in your daily training.  Add extra awareness during your physical workouts.
5	<i>Openness to experience</i> <ul style="list-style-type: none"> <li>– Allowing things to come – letting it be as it is.</li> <li>– Accepting reality is fundamental to successful decision-making.</li> <li>– The problem with controlling thoughts or answering them back.</li> <li>– Exposure to reality (i.e., all kinds of experience) can result in adaptation.</li> <li>– When being non-judgemental feels wrong or contradictory.</li> <li>– Sitting with thoughts as thoughts, and <b>not</b> facts.</li> </ul>	Implement a daily breathing space (1–5 min).

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	<ul style="list-style-type: none"> <li>– Observing the constant stream of consciousness.</li> <li>– First step: the breathing space and separating thoughts from facts.</li> <li>– Second step: Try to savour the moments between thoughts.</li> <li>– Third step: Keep cultivating being calm with a ‘beginners mind’.</li> </ul>	
6	<p><i>Building on the mindfulness-training - Reappraisal</i></p> <ul style="list-style-type: none"> <li>– All mental change starts with accepting your mental state.</li> <li>– Stage 1: Identify your inner state.</li> <li>– Stage 2: Ways to change your inner state (e.g., inner dialogue)               <ul style="list-style-type: none"> <li>- ‘Affirmations’</li> <li>- ‘Stopping’</li> <li>- ‘Reframing’</li> <li>- Humour, music, mind-movies</li> </ul> </li> <li>– How mindfulness-training helps in this process.</li> </ul>	<p>Reframe negative thoughts in everyday life after accepting their presence.</p>

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The 12-month intervention for the combat aircraft cohort contained a few extra elements that were not included in the shorter four-month intervention for the helicopter cohort. Six of the plenary sessions in the 12-month intervention included an additional 1.5 hours which was spent on being mindful during physical exercise. Learning ways to be mindful during physical exercise was an important asset of this intervention, because this was potentially an important future application of MT for the group. They also received a lecture from a former Norwegian Olympic champion in Alpine skiing, on the importance of commitment, motivation and patience. The fighter-aircraft cohort also received a one-on-one session with an MT instructor the day after plenary sessions. Here the participants could ask questions or discuss their practice. The main aim of the one-on-one sessions was to reinforce motivation to continue practice outside the classes. Participants received six text messages reminding them of their daily practice and eight e-mails with theoretical and inspirational information related to mindfulness and MT. In addition to the 10-hour introductory course, spouses and partners were offered evening classes in mindfulness every third week during the first six months of the intervention. The four-month intervention programme did not include

yoga during the weekly plenary practice. Due to space limitations at the helicopter squadron, the body scan was done sitting instead of lying down in study 3.

### Instructions

As the outcomes of any training programme depend on the activities pursued by the participants during the intervention period, the instructions given to participants are of importance. This may be of particular importance in the current thesis, because mindfulness is a loosely defined phenomenon with some variations between MT-programmes and instructors. In the current interventions, instructions were given live by a mindfulness instructor in plenary sessions, and through the pre-recorded soundtracks or self-guiding during the out-of-class training. Participants were encouraged to register inner and outer experiences without manipulation. Therefore, all words pointing at a certain feeling or optimal state were avoided (e.g., relaxed, calm, content etc.). Instructions were conveyed as invitations, in order to avoid triggering unnecessary resistance. In general, silent periods between instructions were maximized to strengthen self-regulation. During the body scan, the instructor guided participants throughout the body, feeling one body part at a time.

The silent meditation involved paying attention to the present moment, flexibly changing between two different attentional strategies, sometimes referred to as concentration- and open-monitoring phases. The silent meditation started with a focused attention phase followed by an open-monitoring phase, spending approximately half the time on each phase. These are excerpts from the manuscript used to instruct the participants:

*Focused attention: Please pay attention to the physical sensation of your breath wherever you feel it most strongly in the body (e.g., nose, chest, stomach). Follow the natural and spontaneous movement of the breath, not trying to change it in any way. Just pay attention to it. If you find that your attention has wandered to something else, gently bring it back to the physical sensation of your breath, with a renewed intention to be fully aware of the sensations of your breath.*

Open monitoring: *Please pay attention to whatever comes into your awareness, whether it is a thought, emotion, or body sensation. Just follow it until something else comes into your awareness, not trying to hold onto it or change it in any way. When something else comes into your awareness, just pay attention to it until the next thing comes along.*

### **Procedures**

Information from the participants was obtained through a mix of objective measures and self-reports on site. Participation was voluntary, and subjects provided written informed consent. All participants attended a pre-meeting, where they were informed about the purpose of the research and the costs and benefits of participation. It was explicitly stated that they could withdraw at any time, and that their withdrawal would have no impact on their professional career. They were informed that the results would be treated confidentially according to Norwegian laws and regulations for handling personal data. It was further underlined that published results would be anonymised, and data presented in a way that would not allow for identification of the participants. All four studies were approved as a whole by the Regional Committee for Medical and Health Research Ethics, Oslo, Norway (Ref. nr: 2011/1679; see appendix).

### **Measurements**

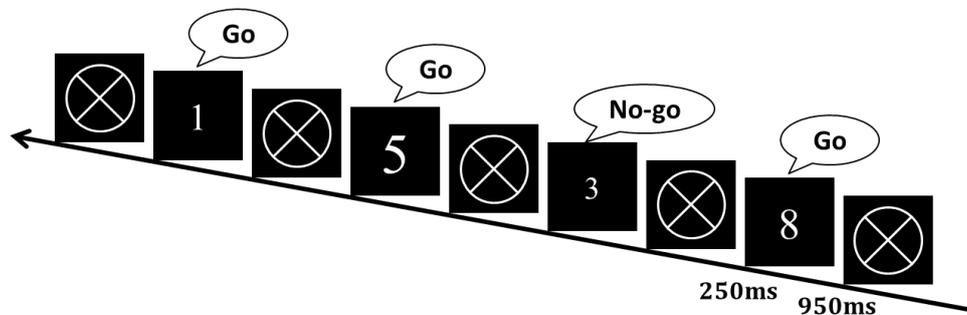
Only standardised measures that had been previously validated were used, except the Norwegian Mental Skills Questionnaire for Athletes (NMSQ-42). However, this has been used for more than a decade by the Sport Psychology Department at the Norwegian Olympic Training Centre, and unpublished data shows a close relationship between athletes' self-assessment and actual mental skills (Pensgaard, 2010). All questionnaires had acceptable reliability with alpha values  $>.70$ .

**Objective (i.e. third person) measures**

**Cortisol (Paper 3).** Saliva cortisol has been used as an outcome measure in mindfulness research (Matousek et al., 2010). Cortisol, the end product of the hypothalamic–pituitary–adrenal (HPA) axis, is one of the biological mediators providing energy to cope with daily demands, and is regarded as a reliable marker of the physiological stress response (Pruessner et al., 1997). The cortisol hormone triggers the release of glucose in the body and is an important part of energy mobilisation and expenditure, but also the wear and tear of the body. Cortisol levels are subject to short-term fluctuations caused by acute stressors, and a slower 24-hr cortisol cycle, closely related to metabolic rate. Cortisol levels are highest during the second half of the night, with a peak level in the morning after awakening, and decline throughout the day with the nadir around midnight (McEwen, 1998; Wilhelm, Born, Kudielka, Schlotz, & Wüst, 2007). Acute exposure to a taxing environment would normally lead to higher secretion of cortisol in healthy individuals, but repeated energy mobilisation without sufficient recovery depletes bodily resources and could lead to exhaustion and lower cortisol secretion. Prolonged periods of high demands have therefore been associated with lower morning cortisol levels, a blunted cortisol awakening response (CAR), and higher evening cortisol values (Schlotz, Hellhammer, Schulz, & Stone, 2004; Kristenson et al., 2012; O'Leary, O'Neill, & Dockray, 2015). Thus, the CAR and cortisol slopes from morning to evening might all be valuable indicators of the capacity to respond to or recover from stressful stimulation. CAR is a measure of the responsiveness to wake-up after awakening; it is calculated as the difference between cortisol levels at wake-up and 30 min after wake-up. High slope is a measure of the maximal dynamic, because it is calculated as the difference between the peak cortisol values 30 min after wake-up to bedtime. Low slope is calculated from the wake-up values to bedtime and therefore excludes the extreme value related to the wake-up response (Kristenson et al., 2012). Moreover, higher CAR scores and steeper slopes could indicate

normal metabolism and sufficient recovery after stressful stimuli, whereas lower CAR and blunted slopes could indicate a lack of recovery.

**SART (Robertson et al., 1997).** The SART is a go/no-go continuous performance task where participants are instructed to respond to the go stimuli (numbers 1, 2 and 4-9) with a key press and to withhold this response when the no-go stimulus ('3') is presented. Subjects are instructed to respond as quickly and accurately as possible. 225 single digits (25 of each of the nine digits) are presented visually. Each digit is presented for 250 msec, followed by a 950-msec mask and the total time of the test is 4.3 minutes.



*Figure 4.* A graphical illustration of the sequence and timing of stimulus events presented on each trial in the Sustained Attention to Response Task (SART).

The SART has been found to be sensitive to transitory reductions in attention, but is found to be mostly related to the response-inhibition (of motor action) element of executive functioning (Cheyne, Carriere, Solman, & Smilek, 2011; Dillard et al., 2014). We chose the SART instead of a more global test of inhibition as it may better map real-life situations in performance environments where ongoing default motor behaviour often must be inhibited due to a continuously changing environment. Successful performance on the SART involves a trade-off between RT and action slips. Compared to speeding up, a slight slowing down of RT decreases the chances of making action slips, but only if accompanied by mindful and

sustained attention (Robertson et al., 1997). An important asset to the SART is that the observer gets no advance information about ‘when’ the target stimuli will appear. This excludes the possibility of anticipation and preparatory actions, which reflects real world scenarios experienced by the participants in question. Another advantage to the SART, compared to traditional formatted tasks (TFTs) is that it strongly relies upon the endogenous sustained attention system. In TFTs, subjects are asked to only respond to rare stimuli in a continuous stream of stimuli. However, the alerting effect caused by the sudden appearance of a target stimulus reduces the demands on the endogenous sustained-attention system (Staub, Doignon-Camus, Desprès, & Bonnefond, 2013). This problem is circumvented in the SART by requiring participants to respond routinely to all stimuli except to an infrequent stimulus (11.1 % of stimuli). Recently, this computerized version of the SART has been validated against actual response inhibition performance during a realistic combat scenario (Wilson et al., 2015).

The primary SART measures of interest in regards to response inhibition are errors of commission (responses to the rare no-go digit: 3), reaction times to frequent go-stimuli and errors of omission (failures to respond to frequent go-stimuli) (Wilson, Russell, & Helton, 2015). Commission errors (controlling for RTs) are regarded as the most interesting measure in relation to response inhibition, while omission errors and variations in RTs have been associated with sustained attention (Cheyne et al., 2011).

*The attentional capture task (ACT; Theeuwes & Chen, 2005).* The ACT is a visual search task where participants are instructed to discriminate the orientation of a target line (vertical or horizontal) placed inside a diamond that appears unpredictably but equally likely in one of six positions equally spaced around the fixation point on an imaginary circle. In 80% of the trials a task-irrelevant peripheral stimulus (i.e., a red blink) flashes for 60 ms, at one of the six positions prior to the target appearance. The attentional capture effect is measured in

five conditions, according to the presence and position of the distractor – *no distractor*: no red-blink, *cued condition*: red blink on target position, *distance 1*: red blink closest to target, *distance 2*: red blink second closest to target, *distance 3*: farthest away from target (Theeuwes & Chen, 2005).

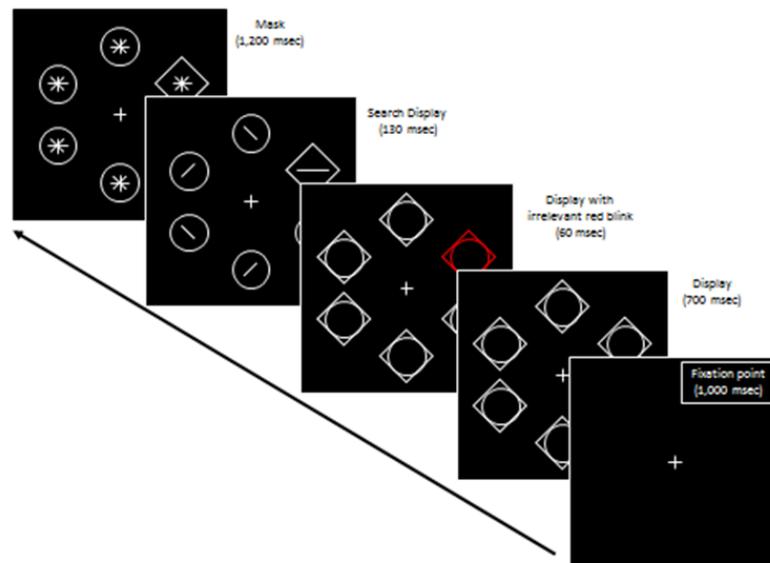


Figure 5. A graphical illustration of the sequence and timing of stimulus events presented on each trial in the Attentional Capture Task (ACT).

Although the attentional capture phenomenon may be trivial to most people, we chose the ACT as a measure of task-irrelevant stimulus processing, as this test specifically maps real-life situations in performance environments where salient irrelevant stimuli are commonly mixed with target-stimuli. An important asset of the ACT is that the observer gets no advance information about ‘where’ the target stimuli will appear. This excludes anticipation and therefore the advantage of narrowing the focus to a specific location, which also reflects real-life scenarios in complex and dynamic environments. Another reason for including the ACT in the current thesis was that MT has been shown to increase rumination

and anxiety in clinical samples, possibly due to hypervigilance and/or hypersensitivity (Segal et al., 2002). There might be a similar effect in high-performance populations affecting visual search behaviour.

To reduce the burden on participants, we used a shortened version of the ACT, based on one of our previous experiments (unpublished work). The task takes 15 minutes to complete. Two scores were derived from the ACT on all five conditions: mean RTs and sensitivity ( $d'$ ) in which the vertical target was discriminated from the horizontal target. Sensitivity was calculated from 'hits' and 'false alarms' (Stanislaw & Todorov, 1999), allowing for the separation of perceptual and decision-level effects of attention.

#### Subjective measurements

**Demographics.** Paper 1 included gender, age, occupational role, marital status, number of children, and combat aviation experience. Paper 3 included gender, age, military experience, and whether respondents were living with a partner or not were recorded. In papers 2 and 4 only gender and age were collected.

**Mindfulness (papers 1, 3 and 4).** To assess mindfulness we used the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). The FFMQ consists of 39 items rated on a 5-point Likert scale, and measures mindfulness on five interrelated subscales: observing, describing, acting with awareness, non-judgemental responses to inner experience, and non-reactivity to inner experience. Pre-intervention mindfulness in study 1 was assessed by administering a retrospective version of the FFMQ post-intervention, because it was considered that many of the items might have caused unwanted scepticism if presented prior to the intervention.

**Mental effort (paper 3).** An important mechanism behind the stress-reducing effects in high performance environments may be the ability to economise mental resources, meaning reduced mental effort during demanding tasks without compromising performance. The

SART is a demanding task where error rates are commonly high (Robertson et al., 1997; Wilson et al., 2015). To confirm this, we measured the pre- and post-subjective demand performing the SART using a subscale of the NASA Task Load Index (NASA-TLX). The participants rated one item on a 20-point Likert scale ranging from 1 (not demanding at all) to 20 (very demanding) (Hart & Staveland, 1988).

***Mental skills (paper 1).*** Self-perceived mental skills were assessed by the NMSQ-42. The questionnaire consists of 42 self-statements rated on a 10-point Likert scale ranging from 1 (I totally agree) to 10 (I totally disagree), and includes six subscales: operational preparations, visualization, inner dialogue/confidence, arousal regulation, attention regulation, and goal setting. The questionnaire has been used for more than a decade by the Sport Psychology Department at the Norwegian Olympic Training Centre, and unpublished work shows a relationship between athletes' self-assessment and actual mental skills (Pensgaard, 2010).

***Anxiety (paper 1).*** Performance-related anxiety was assessed by a Norwegian version of the Sport and Anxiety Scale (SAS; Smith, Smoll, & Schutz, 1990), validated in a Norwegian sample of athletes (Abrahamsen, Roberts, & Pensgaard, 2006). The SAS consists of 21 items rated on a 4-point Likert scale ranging from 0 (not at all) to 3 (very much). The subscales are somatic anxiety, worry, and concentration disruption.

***Depression (paper 1).*** We used a Norwegian version of the one-dimensional 10-item Hopkins Symptom Checklist (HSCL; Strand, Dalgard, Tambs, & Rognerud, 2003). Responses are given on a four-point scale ranging from 0 (not at all) to 3 (very much).

***Program feedback (paper 1).*** The participants received a questionnaire post-intervention on which they were asked to rate the programme, their own effort, and how useful they found the different elements of the training.

*Interviews and email (paper 1).* As part of the evaluation process we conducted a face-to-face post-intervention interview with all participants. This added to the quantitative data and provided more detailed insight into the participants' experiences. To maximise the informative value of both costs and benefits of MT we started by asking whether they had experienced any notable changes during and/or after the MT intervention. If so, they were then asked to describe these in more detail.

### **Methodological Concerns**

Many of the limitations to this thesis result from the constraints of conducting research on high performance cohorts, where there is limited access. This results in naturally small sample sizes which limits the use of experimental designs and extensive statistical analyses. Small sample sizes increase the possibility of committing Type II errors as we may not have the power to reach statistical significance. Furthermore, it does not allow for mediation analysis or analysis of different subgroups, which may have given us useful additional insight into the underlying mechanisms. There is also an increased possibility of committing a Type I error as we were unable to recruit a control group in study 1 or to give the participants in the control group in study 3 an activity similar to MT, but without the active ingredients of MT. An active control condition (e.g., relaxations or positive thinking) is important to exclude the natural effects of an intervention which are not specifically related to the MT per se.

The combined length of the interventions and the follow-up period in the first study seemed to have been sufficient to elicit and detect some of the long-term benefits of MT which other studies have failed to capture. However, the lengthy multifaceted MT intervention with only pre- and post-measurements also poses some limitations to the reliability of the data. We cannot say anything about the temporal variation and changes throughout the intervention period. It becomes difficult to separate the effects produced by MT from those attributable to other factors. It is also difficult to sort out whether or how the

components included in the programme work separately or whether the effect would change by adding or subtracting different components. On the same note, the retrospective design of study 1 and the use of verbal statements and self-reports could also be of concern. One might question to what degree the responses are truthful, due to, for example memory problems and response biases or how their experienced effects of the MT affected their memory. The fact that participants in all studies could be considered convenience samples, further limits the findings, together with the fact that there was no random assignment or blinding to units or individuals in the intervention studies (papers 1 and 3).

A methodological issue tied specifically to the computerised measures is that the SART and ACT are general tests conducted under specific laboratory conditions, and lack resemblance to real life scenarios. Indeed, the value of a test is closely related to whether the demands in the test are similar to the skills necessary to demonstrate expert performance in real life settings. Therefore, it is uncertain whether the same pattern of performance would be observed in the participants while performing a real life soccer task, for which they have received special training and are highly experienced. That being said, a challenge with maximising face validity is that tests tend to be more complex and involve several sub-skills to perform. Substantial systematic variance in several processes makes it difficult to cleanly capture the variance of one measure of interest. For example, a score derived from a test closely resembling soccer, would necessarily include systematic variance attributable to several contextual sub-processes (e.g., object recognition, multiple tracking, memory, attentional shifts, and emotional processing).

Based on these concerns there is a need to be careful when interpreting the data. Nevertheless, it is virtually impossible to obtain reliable data of this kind during soccer play or real life operations. The use of a mix of methods in the current studies allows for new knowledge and insights into an under researched area in high performance cohorts.

## Results

### Summary of the Papers

**Study 1 (paper 1)** aimed to test the feasibility of a one-year MT programme in a male high-performance combat aircraft unit ( $n = 21$ ) and was designed as an uncontrolled intervention study using self-report measures. Pre- to post-analysis showed significant positive changes in self-reported somatic anxiety, attention- and arousal-regulation. The participants reported an increase on all facets of mindfulness, with elevated levels remaining throughout the two-year follow-up. Participants reported MT having operational benefits, and that the body scan and sitting meditation were the most useful elements of the intervention. The exact level of benefit varied among participants, but the general levels of mindfulness and other self-reported beneficial effects increased from pre- to post-intervention and lasted throughout a two-year follow-up. The study demonstrated that MT may be successfully implemented in a high performance combat aircraft cohort.

**Study 2 (Paper 2)** aimed to investigate the sensitivity of the SART and was designed as a blinded and pseudorandomised experiment including 19 orienteering runners competing at a national level. The results from this study indicated that errors of commission increased during WBV. After controlling for mean RT in the WBV condition, errors of commission were no longer correlated with other SART variables, indicating that the increased frequency of errors was related to a speed accuracy trade-off (i.e., a speeding of response times during WBV). The findings of this study imply that WBV affects inhibitory functioning more than sustained attention, and that the SART could be a useful measure of response-inhibition in high performance individuals.

**Study 3 (Paper 3)** aimed to test the interventional effects of four-month MT during a prolonged period of high workload, on measures of stress, response inhibition and stimulus

driven attentional capture. We used a non-randomised (waitlist) controlled design comprising 35 male participants. Performance on the SART and ACT, saliva cortisol, and perceived mental demand imposed by the SART were the outcome measures. MT participants ( $n = 25$ ), compared to controls ( $n = 15$ ), had a larger pre to post increase in high- and low-cortisol slopes, and a larger decrease in perceived mental demand imposed by the SART. These results partly confirmed the findings of study 1 and suggest that MT may alleviate some of the physiological stress responses and the subjective mental demands imposed by stressful situations and periods of high workload.

**Study 4 (Paper 4)**, after abandoning the aim of evaluating the effects of a MT-intervention due to a lack of post-intervention data we aimed to investigate the association between the various facets of mindfulness, response inhibition and inhibition of task-irrelevant processing in elite soccer players not exposed to MT. The study-design became cross-sectional based on the test scores of 42 professional male soccer players on the SART, ACT and mindfulness (FFMQ). We found that players high on the observe facet of mindfulness made fewer errors of commission on the SART. Those high on the observe facet also demonstrated more efficient use of a salient stimuli (i.e., red blink) in the ACT, when it acted as a clue for the upcoming target, without becoming more distracted by the same cue in the distractor conditions. Higher scores on the non-judgemental factor were associated with more errors of commission on the SART and lower sensitivity ( $d'$ ) to target on the ACT. These findings suggest that there is both a positive and negative relationship between facets of mindfulness, response inhibition and task-irrelevant stimulus processing in these MT-naive professional soccer players.

## Discussion

Being prepared to perform optimally in environments that are complex, rapidly changing and inherently stressful is challenging. Thus, the need for effective interventions for stress-reduction and improved inhibitory control is clearly important. MT has been put forward as a useful performance-enhancing tool for individuals operating in extreme environments in sports (Birrer et al., 2012; Gardner & Moore, 2004) and in the military (Fornette, Bourgy, Jollans, Roumes C, & Darses, 2014; Jha et al., 2010). Nevertheless, there is a lack of empirical evidence of the effects of MT in high performance environments. The overall aim of this thesis was therefore to test the implementation, feasibility and effects of MT in high performance cohorts. We wanted to highlight aspects related to stress-reduction and the inhibition element of executive control. A mix of subjective and objective measures were used to assess the level of mindfulness, mental skills, stress-response and inhibitory control before and after two MT programmes of similar structure but of different duration.

Although the knowledge about the potential benefits of being mindful also on the elite level are intuitive, and have been readily available, high performance environments may have been hesitant to apply MT because some believe it could trigger unintended scepticism. An important finding was therefore that the MT-programmes delivered as in the current studies (paper 1 and 3) did not trigger much unintended scepticism in the participants. We found support for the vision that MT could be a useful strategy for protection against stress-related fatigue and attrition effects of extended periods of high workloads also in high-performing individuals. We found no evidence of improved inhibitory control after a four-month MT programme, but we did find associations between the level of mindfulness and the measured categories of inhibition in the soccer cohort. This indicates that inhibitory control at the level of response inhibition and stimulus driven attentional capture are not easily changed by MT,

but may be associated with certain facets of trait mindfulness prior to engaging in MT. It should be mentioned however, that a recent analysis of the pre-intervention data in the helicopter cohorts (paper 3) did not reveal the same associations between mindfulness and performance on the SART and ACT (unpublished work). One possibility is that our findings in paper 4 are incidental or that these associations are different across high performance cohorts.

Only a few studies have previously investigated MT in high performance environments (Birrer & Morgan, 2010; Fornette et al., 2012; Jha et al., 2010; Jha et al., 2015; Jha et al., 2016; Sappington & Longshore, 2015). These studies have applied shorter and less comprehensive interventions than in our current research. Cultivating mindfulness is regarded as a lengthy process, and attending a structured course, like the eight-week MBSR programme, is merely supposed to initiate this process (Kabat-Zinn, 1994). Thus, this report on lengthy MT interventions in high-performance groups with follow-up is extending the knowledge in the field of MT research. We believe this is also the first report on the association between the different facets of mindfulness and objective measures of inhibitory control in elite cohorts. The mix of longitudinal and cross-sectional designs gives comprehensive insight into the benefits and limitations of being mindful or engaging in MT. The use of third-person objective measurements also eliminates some of the bias involved in studies exclusively relying on subjective measures. Study 2 is unique by examining the effect of a specific environmental stressor on response inhibition, excluding the effects of perceived workload and discomfort during the task.

### **Mindfulness and Stress-Reduction**

The main finding of the current research was MT's salutary effects on stress-reduction (studies 1 and 3). This confirmed previous research on highly stressed workers and patient populations showing that being mindful and engaging in MT may act as a preventive buffer

towards the negative effects of stress (Cohen et al., 2007; Klatt et al., 2015; Nyklicěk et al., 2013). Our findings extend this work and showed that this was also the case for elite cohorts exposed to persistent high workloads. From the current research we cannot pinpoint the exact mechanisms behind how MT made participants more resilient to the pressures of everyday life. The design of the MT intervention could, of course, have played a role in stress-reduction, for example the plenary layout of the training sessions. Simply spending more time together in plenary sessions could have led to an increased sense of social support. The stress-reducing effects of social support are documented in elite athletes in high stake competition (Kristiansen & Roberts, 2010) and workers in demanding occupational settings (Bragard, Dupuis, & Fleet, 2015). The anecdotal evidence of improvements in interpersonal relationships from the interview data in study 1 supports this explanation. It is also possible that spending three to five hours a week sitting or lying down in itself could have had a relaxing and restorative effect on the participants. An important finding is however, that there were no indications that the stress-reduction could be attributed to changes in outer workload, more positive outcome beliefs, more physical activity, time of wake-up, or better or longer sleep. The fact that we observed changes in self-perceived mindfulness in the groups receiving the MT-programmes also suggests that at least some of the beneficial effects were due to adoption of specific mindfulness skills.

On a general level, neuropsychological research suggests that MT improves self-regulation, through increases in emotion regulation, attention-control and self-awareness (Tang et al., 2015). Improvements in emotion regulation, due to MT are supposed to be especially related to stress-reduction through adaptation processes (Hölzel et al., 2011). Fundamental to adaptation is exposure to inner sensations, and increased openness to sensations is therefore an important asset of being mindful in this respect (Bishop et al., 2004). Thus, a plausible explanation to the stress reducing effects of MT in the current research

could be related to the MT practice of openly observing and exposing oneself to inner and outer experiences with an attitude of curiosity and acceptance, rather than automatically (over)reacting. This practice could reduce the impact of thoughts and feelings tied to past and future events and thus over time change the response to potential stressors (Bishop et al., 2004). Instead of focusing on ‘why’ they feel a certain way (e.g., irritated or fed-up), this ability to be fully aware of the exact physical sensations tied to intense feelings may have counteracted reacting emotionally in an automatic fashion. It may also be that an increased ability to maintain an open and non-judgemental stance has left them with the chance to adapt to potential stressful stimuli also through a refined view of their primary sensations and their validity.

The theory that attending mindfully to stressful stimuli would extinguish our negative emotional reactions has not been rigorously tested until recently. A controlled study was undertaken to test this theory using an electroencephalogram (EEG) to measure the effects of repeatedly viewing negative and neutral images under both mindful and control conditions (Uusberg, Uusberg, Talpsep, & Paaver, 2016). They found that repeated viewing of emotionally-charged images while maintaining mindful awareness was associated with greater reduction in emotional reactions to the images than viewing them without being mindful. They also found that trait mindfulness was associated with lower response to negative images also when not actively deploying mindful awareness. This supports the theory that increasing trait mindfulness may increase stress-resilience in a bottom-up way, which makes it especially suitable to high performance individuals. This has been confirmed in a study of elite BMX cyclists (Haase et al., 2015).

We also believe that a more economical and efficient use of attentional resources may have played a part in the stress-reducing effects of MT in our elite groups. Controlling attention is an energy-intensive (Warm, Parasuraman, & Matthews, 2008), finite resource

(Schneider & Shiffrin, 1977). Thus, letting the attention ‘rest’ on an object or task, and gently bringing it back when focus is lost as instructed in MT, is a less energy demanding mental strategy than forcefully holding the attention in place and judging oneself when focus is lost. The interview data in study 1 and the reductions in mental demand on the SART in study 3 support this.

According to some researchers, MT should also increase adaptive thoughts and feelings and not merely limit the impact of maladaptive thoughts (Rapgay & Bystrisky, 2009). In concert with this, the ‘broaden-and-build theory’ proposes that an openness to all sensations combined with a broadening of perspective, which is learned in MT, prevents maladaptive thoughts and feelings from interrupting recovery processes, but also opens up the possibility of positivity and fulfilling experiences (Garland, Farb, Goldin, & Fredrickson, 2015). Indeed, we found anecdotal evidence of an increase in life-fulfilling experiences after the MT-program in the interview data in study 1. At the same time, we did not find changes in the levels of positive response outcome expectancies (PROE) in study 3. However, this may have been due to ceiling effects. Nevertheless, the production of adaptive and positive thoughts and feelings as a result of MT should be further addressed in future studies. Particularly because employee positivity and well-being may reduce turn-over and attrition in the workplace (Danna & Griffin, 1999).

The above mentioned mechanisms may have worked separately, but they have probably also worked in concert. For example, a change to a more controlled and efficient attentional strategy would lessen the expenditure of attentional resources, while at the same time this would help short circuit rumination and stressful future focus opening up for adaptive thoughts. All of which retain limited energy reserves, thereby leaving the participants with a surplus of energy.

### **Mindfulness and Inhibition**

Previous research has found that mindfulness and engaging in MT are associated with enhanced global attention-regulation abilities, including manipulation of the orientation and aperture of attention, monitoring, detecting and disengaging from distractors and inappropriate action, and the ability to reorient attention toward a chosen object (Chiesa, Calati, & Serretti, 2011; Jha, Krompinger, & Baime, 2007; Lutz, Jha, Dunne, & Saron, 2015; Tang et al., 2007). We found confirming evidence of improvement in attention regulation in the increases in self-reported control and economisation of mental resources in the military aviation units (papers 1 and 3). We also found beneficial associations between trait mindfulness and performance on the computerised tests of inhibitory control in the professional soccer cohort (paper 4). The link between the observe facet of mindfulness and performance on the SART was positive and can be readily explained by a heightened openness to experience. A heightened level of openness to experience is not only an important mechanism behind the stress-buffering effects of MT, it is also key to the beneficial link between mindfulness and inhibitory control. Being open to all stimuli, including potential stressful experiences, presumably fosters an increased sensitivity and responsiveness to emotions, including the short and transient affects which are associated with recruitment of higher order control mechanisms (Weinberg et al., 2012). This may have been particularly influential in the current elite cohorts who are used to performing under considerable inner and outer perturbations. We cannot say whether this association is different from the normal population due to the lack of previous research investigating mindfulness. However, recent research has shown that elite athletes have the ability to pay close attention to bodily signals and are superior in generating anticipatory prediction errors in the presence of significant perturbations (Paulus et al., 2012). Although speculative, the observe facet of mindfulness

may be an important asset in this capacity. If so, one could tailor future MT interventions to specifically target this facet if the goal is to improve higher order control processes.

Despite evidence of improvement in self-reported attention regulation after 12 months of MT (paper 1), we found no change in performance scores on the SART or the ACT after four months of MT (paper 3). This discrepancy may be due to differences in group characteristics, intervention or methodology. There is evidence of a dose-response relationship in MT (Carmody & Baer, 2009), and we cannot rule out that a lack of positive findings in study 3 was due to the shorter length of the intervention. However, we find this unlikely as previous studies on similar cohorts have found pre- to post-improvements on SART measures applying eight week interventions (Jha et al., 2015; Jha et al., 2016). We also found clear evidence of increases in the levels of mindfulness and a reduced stress-response in both of our interventions, suggesting the training-dose in the current research was sufficient. A plausible explanation to the discrepancy between the results in studies 1 and 3 is most likely due to differences in methodology. The SART and ACT are limited to measuring inhibitory functioning, while the items in the self-report measure of attention-regulation in study 1 reflect more global attention skills, similar to those measured in previous research (Chiesa et al., 2011; Jha et al., 2007; Lutz et al., 2015; Tang et al., 2007). However, we believe this discrepancy is of minor concern, and can be readily explained by stress-reduction and changes in subjective mental demands and effort.

Differences in mental effort seemed to have played a major part in the current studies. In study 1 participants may have felt an improvement in attention regulation after receiving MT since their perceived task demand was less when performing challenging daily tasks post-intervention. This explanation is supported by our findings in study 3, where the MT group felt they had to deploy less mental effort than the control group during the SART after having been exposed to MT. The fact that the MT group was able to get an adequate task

performance with less mental effort is an important finding, as this would be highly beneficial in performance cohorts where individuals must endure long and demanding work hours. That being said, we cannot exclude the possibility that if the MT group had put more mental effort into the task they would have performed better than the control group. We find this explanation less likely as designs such as the SART and ACT are thought to be among the least affected by confounding effects of mental effort (Jensen, Vangkilde, Frokjaer, & Hasselbalch, 2012). The reason for this is that the occurrence of the signal-stimuli cannot be anticipated by the participants in these tests. In the SART the participant has no information about when the next digit '3' will appear, while in the ACT they have no information where the vertical/horizontal target stimuli will appear. This means that beyond paying attention to the task, trying very hard seems to be ineffective to improve performance on any of these tests.

We could not find evidence of improvements in performance on the ACT and SART. This is contrary to the two previous studies on military personnel finding pre to post improvement in SART performance after engaging in MT (Jha et al., 2015; 2016). We believe this is due to differences in methodology, as they used a version of the SART which is four times longer than the standard version we used (Robertson et al., 1997). As the duration increases, the SART becomes more sensitive to lapses in sustained attention than response inhibition per se. Thus, we might have found similar results in our studies if we had applied this extended version of the SART. However, our main aim by applying the SART was to investigate response inhibition.

Our findings are still contrary to several previous studies showing a consistent and beneficial link between mindfulness and the inhibition element of executive functioning (for review, see Gallant, 2016). We believe this may be related to methodology and the level of specificity of the SART and ACT. The SART and ACT are specifically designed to tap response inhibition and task-irrelevant stimulus processing, which relates to early processes in

the perceptual-action sequence (Robertson et al., 1997; Theeuwes, 2014). Indeed mindfulness has been associated with benefits in both early- and late perceptual processing (Chiesa et al., 2011; Jensen et al., 2012; Moore & Malinowski, 2009). However, any improvements or variance in more global inhibitory control affecting late perceptual processing will not be captured by the current form of ACT and SART. Many previous studies investigating mindfulness and inhibitory control have used the Stroop-test (Stroop, 1935). The Stroop-test comes in different versions, which all measures more global inhibitory control. In the classic test, participants' responses to indicate the colour of words that are congruent with the meaning of the word (e.g., the word 'red' in red ink) are compared to responses when the colour of the word is incongruent with its meaning (e.g., the word 'red' in blue ink). The Stroop-effect is the finding that participants are slower at the incongruent condition than the congruent.

Unlike the SART and ACT, the Stroop-test is sensitive to attentional processes both early and late in the perceptual pipeline, meaning that it would be sensitive to changes in the entire perceptual-action sequence (i.e., from stimuli presentation to late decision-making). Some would argue that the specificity of the SART and ACT would be an important limitation to the current study, and that a more global test of inhibition would have been more appropriate to changes brought about by comprehensive MT-interventions. However, this would have involved an additional test and a bigger burden on the participants, as the obvious drawback of choosing the Stroop-test instead of the SART and ACT would be that we could not pinpoint how mindfulness affected and related to inhibition during early processing.

The negative association between being non-judgemental and performance on the SART and ACT in MT naïve soccer players was surprising and contrary to theory suggesting that higher levels of mindfulness should involve a heightened receptiveness to the affective responses signalling the recruitment of higher order control mechanisms (Weinberg et al.,

2012). In fact, the non-judgement facet has previously been found to be particularly associated with higher order control in experienced meditators (Teper et al., 2013). Finding the opposite association indicates that MT naïve professional soccer players with higher levels on the non-judgement facet lack openness to experience. This would not come as a surprise to those in the mindfulness field underscoring that actively engaging in any kind of attitude would be incompatible with being truly open and present with all experience (Ragay & Bystrisky, 2009). These authors would probably also argue that this limitation is hidden to the observer, as they argue that true openness is a learning process that goes through present-centred awareness and not through an active engagement in a non-judgemental attitude. This is not controversial, as this is reflected in MT instructions (including the ones in the current interventions) which do not instruct applying any attitudinal orientation. In other words, the items in the FFMQ making up the non-judgement facet may have a different meaning for MT-naïve individuals compared to experienced practitioners. Unfortunately, the difference in interpretation of items depending on MT experience has been addressed as a general challenge with using self-reported measures of mindfulness (Baer et al., 2006). Thus, this issue should be a prioritized aspect to resolve in order to improve the conclusions that could be drawn from future mindfulness research.

It should also be noted that the non-judgemental facet have previously been associated with some controversy in performance environments (Birrer et al., 2012). Anecdotal evidence from studies 1 and 3 suggests that the non-judgemental facet caused similar controversy and scepticism also among the participants in the current research. That being said, as training progressed, they reported that their scepticism ceased. Nevertheless, these findings further fuel the debate about the feasibility of being non-judgemental in sport contexts where it is recognised that self-evaluation, being 'judgemental' and refrain from engaging in moment-to-moment action control can also be helpful (Birrer et al., 2012). Whether this controversy has

important consequences could not be further resolved in the current study. Thus, the question of whether this is a problem, and if so, whether it is specific to this MT naïve soccer population and if it can be effectively reduced through MT, remains.

### Limitations

While these practice related stress-reducing effects and links between mindfulness and inhibitory control are new and intriguing, we acknowledge that the studies in the present thesis are limited in multiple ways. Most of these limitations are thoroughly described in every paper and at the end of the methods section. Moreover, from the current findings we do not know if MT is better than other interventions. We cannot entirely exclude the possibility that some of the stress-reducing effects of MT are attained through a reduction in overall alertness and situational awareness. More importantly, since we did not apply computer tests in study 1, we cannot rule out the possibility that the 12-month MT programme only improved self-perceived attention control in the combat aircraft cohort. Objective performance measures are also lacking in our studies, meaning it is uncertain how our findings apply to actual flying performance or soccer performance. The fact that I was one of the MT instructors may also be regarded a limitation, as my personal involvement may have biased the responses of the participants and my interpretation of the results. Some would also argue that our use of a mindfulness questionnaire measuring general mindfulness during daily life would be a limitation, as it would not capture mindfulness during competition or high stake performance situations (Thienot et al., 2014).

Although the groups may be representative of high-performance environments, generalising the findings to other high-performance groups may also be problematic. First of all, the intervention studies only included male participants from military aviation who might have been extraordinary in some way. For example, military aircraft-personnel constitute a unique population as they in addition to the risk involved in flying have to follow the requirements of being in the military. They may therefore not respond to interventions in the same way as other high-performance cohorts. In a similar way generalising our findings to younger populations may also be problematic. Particularly because preliminary findings

suggests that MT interventions may have limitations when delivered to young high performance populations (Bernier, Thienot, Pelosse, Fournier, 2014).

### **Practical Application of the Results**

MT had previously been shown to be effective in reducing systemic arousal without compromising alertness in the normal population (Ditto et al., 2006; Tang et al., 2007; Tang et al., 2015) the current research indicated that this also applies to elite cohorts. MT might therefore be an important complement to top-down positive thinking and reappraisal strategies in elite cohorts. As the training could impact bottom-up emotion-regulation, it may be especially suitable for emotion-regulation in individuals exposed to complex and rapidly changing environments, where there is not always time for top-down driven regulation strategies.

As we set out, one of our greatest concerns was the potential costs of MT. For example, there was some evidence suggesting that becoming more attuned to inner present-moment experience could lead to both hypersensitivity and hypervigilance (Segal et al., 2002; Wells, 2011), and in sport contexts these and similar aspects of mindfulness have been questioned (Birrer et al., 2012). Finding no change in performance scores on the SART and ACT was therefore an important and positive finding for those who want to use MT for other purposes (e.g., stress-reduction). This means that the risk of affecting response inhibition and inhibition of task-irrelevant stimulus processing in negative ways seems low (i.e. as measured in the current studies).

However, MT should be liberally sprinkled with caveats and warnings when applied to already high-performing groups where the costs of an intervention could easily outweigh the benefits. In other words, MT should not be treated lightly by those responsible for implementation. MT exercises may be simple to instruct, but the implications and challenges tied to a comprehensive MT-intervention are sometimes difficult to grasp or handle for an

unexperienced MT practitioner. For example, the increase in exposure to inner and outer experiences is an important adaptive process and one that plays a role in delivering the benefits of MT (Hölzel et al., 2011). However, we had participants in the current study who experienced increased rumination and unease during the initial phases of the training. Although challenging and counterintuitive to some, such experiences should be considered a common effect of MT and should not be avoided. We therefore strongly recommend that implementation is led by experienced MT instructors with clear understanding of the theoretical underpinning of MT.

A lack of motivation was another challenge during the delivery of our lengthy MT interventions. This should not be regarded trivial as motivation to engage and complete the required personal practice is critical to the effectiveness of MT. This was particularly challenging in the current research, because life in a military aviation squadron is characterised by a strict schedule and the time spent on MT could potentially be spent on other important tasks. The experiences from our current research and the feedback from the participants may give important advice on how to counteract a drop in motivation.

First of all, the intervention should be carefully tailored to fit the high-performance group receiving it. This is why we copied some of the mental preparation activities used by elite athletes, without departing from the essence of MT. Only later in the intervention we related the MT to its roots in Buddhist philosophy and psychology. Since I am a military officer, I could facilitate programme acceptance due to knowledge of the military community and culture. The fact that the squadron leaders were role models in getting their personal training done between the plenary sessions in this study also seemed important for general compliance with the intervention and integration of MT into operational life. Furthermore, we introduced participants' partners to MT as life at home is a potential arena for realising joint benefits of MT. Several participants stated that without the involvement of their partners they

would have found it difficult to keep up the practice. Another unique asset of the 12-month intervention was that in six of the plenary sessions we included an additional 1.5 hours which was spent on being mindful during physical exercise. Learning ways to be mindful during physical exercise could be an important future application of MT also in other performance groups with strict schedules. In sum, these were all measures which may have impacted the motivation and compliance in the current studies, and thereby impacted the effectiveness of the MT interventions. However, whether or not these elements should be included in future MT-interventions should be subject to careful considerations. First, based on the design of our current research we can say nothing of the exact impact of each of these elements. Second, some of the elements may considerably increase the administration and cost of an intervention.

We are also restricted by our design to give clear recommendations on the length of an MT programme. Although we applied two comprehensive interventions of different lengths, we did not compare these with short and brief interventions. However, the combat aircraft personnel underscored the importance of a long and comprehensive intervention. The participants reasoned they needed time to get used to the practice and experienced more benefit from the intervention the last 6 months of the 12-month programme. Based on our feedback data, when time is limited an intervention including only on sitting meditation, body scan, and preferably a few discussion groups might be worthwhile. Still, the exact minimum length of an effective MT-intervention is a question for future research.

We only tested MT in high performance military aviation units and in soccer<sup>2</sup>. It is therefore debatable whether being a mindful high performer is preferable in all settings and contexts. Until we have more sound evidence underlying this notion, applying MT in high performance environments should be closely monitored for both costs and benefits. Nevertheless, our findings suggests that if delivered with enough attention to scheduling of

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<sup>2</sup> Without any post-tests usable for analysis in the soccer cohort.

the group, a comprehensive MT-intervention programme could be an acceptable and useful intervention in high-performance populations comparable to the groups in the current studies. We found that MT-programmes may be applied to produce general benefits for participants' professional and private lives, and when it came to stress and economising mental resources, engaging in MT seemed to be particularly feasible.

Methodologically, the current research demonstrated the importance of mixed methods and designs to discern some of the multitude of effects and variance of comprehensive interventions. It further underscored the importance of multidimensional measures of mindfulness and demonstrated that the ACT and SART may be easily accessible and useful markers of response inhibition and inhibition of stimulus driven attentional capture.

### **Future Research**

We have only investigated a small area of potential benefits and costs of being mindful and engaging in MT. Although we touched upon the wide range of effects in the interview data in paper 1, there may be many more reasons to implement MT in a work environment (Good et al., 2016) and in sports environments (Birrner et al., 2012). As many high-performance environments rely on well-functioning teams, studies on the between-individual effects of being mindful or engaging in MT might be particularly useful.

Also within the narrow scope of this thesis, our findings have probably generated more questions than answers. We did find that the current MT-programs helped to reduce stress and economise mental resources in high performance populations, but we do not know whether MT is more efficient than other mental training methods. MT has been found to be superior to physical relaxation for healthy adults across ten studies (Sedlmeier et al., 2012), but they found no strong evidence suggesting MT is more effective than other meditation practices. To answer this question one would need RCTs where MT is compared with control groups that receive an intervention that is similar in layout and time spent with the participants, but based

on different principles (e.g., relaxation, positive thinking etc.). This becomes an important path to follow in future research, especially because other and ‘simpler’ stress management programmes without meditative training have been found to have similar mean effect sizes ( $d = 0.50-0.60$ ) as those involving meditation (Richardson & Rothstein, 2008).

Another unanswered question is: What is the required practice-time? Previous research has shown that course hours did not predict larger effect sizes across 30 mindfulness studies of mixed samples (Carmody & Baer, 2008). Only 13 out of 24 studies found that increased compliance was associated with increased treatment effects in mixed samples (Vettese, Toneatto, Stea, Nguyen, & Wang, 2009). Another review reported that course length (6-12 weeks) was not associated with mean effect sizes for work-based MT interventions (Virgili, 2013). A large systematic review and meta-analysis of MT-interventions for healthy samples found that number of treatment days were not related to treatment effect sizes (Sedlmeier et al., 2012). To answer this question there is a need for well-designed dose-response studies. However, proper dose-response studies can only be undertaken when the quality of training is accounted for. The lack of a reliable measure of the quality of training is a limitation to most research on MT, and should be addressed in future studies. This is important as the outcome of any training intervention probably depends on what participants actually do during training. Like in the weight room, everyone may receive the same instructions but individuals perform the exercises very differently. We also know from physical training that if the skills in question are no longer challenged in the individual there might even be decrements in performance.

Another area to pursue is individual and temporal trajectories. We, and others, have found that people benefit from MT, but there are also individuals who do not, and some even experience negative effects from the training. It may also be that training mindfulness implies rapid gains or slow, steady growth – or even a decline on some parameters. These individual

and temporal trajectories were briefly investigated in study 1 of this thesis, but should be more thoroughly investigated in order to maximise effects and reduce the costs of future interventions. In regards to improving cost-effectiveness, mindfulness interventions delivered by technology (i.e. web-based and smart phones) without facilitator involvement may also be a fruitful path to investigate as there are several studies suggesting that such MT-programs are effective (for review see, Fish, Brimson, & Lynch, 2016).

We found that our MT-programs did not affect performance on the SART or ACT. As these tests mirror important capacities in high performance environments, other training methods that could reduce the negative consequences of impulsivity and attentional capture should therefore be explored and investigated. Interventions involving implicit learning could be an option, as recent findings have found beneficial effects of such learning strategies on automatic search behaviour in elite athletes (Bernier et al., 2016). Although our approach using general tests of perceptual skills is important, future research in this area should also include more specific tests performed in more naturalistic settings together with performance specific mindfulness measures. Finally, no studies have investigated if high-performing athletes and operators change their levels of mindfulness merely through their daily training and preparations, without engaging in formal MT.

## Conclusions

Paper 1: A 1-year MT programme successfully increased self-reported mindfulness and was found to be feasible and acceptable for implementation in an elite military aviation population. The programme effectively increased self-reported mindfulness, attentional regulation and arousal regulation, while reducing already low levels of anxiety. Higher levels of mindfulness remained throughout a two-year follow-up period, indicating that the intervention had some long-term effects.

Paper 2: Response inhibition was significantly reduced during WBV in an elite orienteering cohort. The SART can therefore be a reliable marker of subtle reductions in response inhibition during WBV.

Paper 3: A four-month MT programme had a restorative effect on a high performance aviation unit exposed to a prolonged period of high workload. The intervention effectively increased saliva cortisol slopes and reduced self-reported mental demand on the SART, but did not affect response inhibition or inhibition of task-irrelevant stimulus processing (i.e. attentional capture).

Paper 4: Response inhibition and stimulus-driven attentional capture were differentially related to specific facets of mindfulness in professional soccer players not exposed to MT. Being naturally high on the observe facet was associated with better response inhibition and better attentional flexibility on the ACT. Being naturally high on the non-judgement facet was associated with impulsive responding and lower levels of response inhibition.

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## Paper I-IV

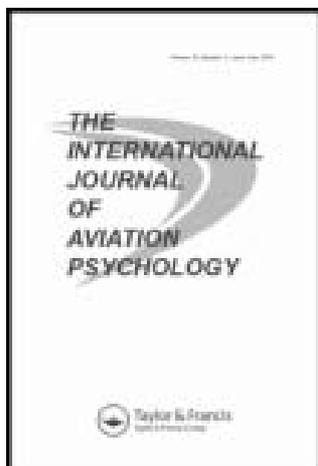


## PAPER I

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### Mindfulness-Based Mental Training in a High-Performance Combat Aviation Population: A One-Year Intervention Study and Two-Year Follow-Up

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## Mindfulness-Based Mental Training in a High-Performance Combat Aviation Population: A One-Year Intervention Study and Two-Year Follow-Up

Anders Meland,<sup>1</sup> Vivianne Fonne,<sup>1</sup> Anthony Wagstaff,<sup>1</sup> and Anne Marte Pensgaard<sup>2</sup>

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This study tested the feasibility and value of mindfulness training (MT) in a Norwegian military combat aircraft squadron ( $n = 21$ ). No objective measures of performance were included in this study. Subjective measures of mindfulness, mental skills, and performance-related anxiety were administered before and after the intervention, including a semistructured interview at the study's conclusion after the intervention. Qualitative feedback and measures of mindfulness were collected via e-mail at 12 and 24 months during follow-up. During posttraining, there was a reduction in somatic anxiety related to performance and improvements in self-perceived skills associated with mindfulness, attention regulation, and arousal regulation. Mindfulness scores remained higher throughout the follow-up. Time-consuming plenary sessions and the amount of recommended, out-of-class training were found to be potential drawbacks of MT. Overall the findings indicate that MT might be a viable complement to existing mental training for high-performance populations.

At the core of safe flying lies the capability of regulating and focusing attention (Stanton, Chambers, & Piggott, 2001). Failing to identify important changes or pay attention to what is relevant in a given situation can have serious consequences in aviation. Self-regulation of attention is considered the gateway to perception and is fundamental to vigilance, emotion regulation, and cognitive skills (Jha, Krompinger, & Baime, 2007). Previous research has shown that 75% of pilot errors result from poor perceptual encoding (Jones & Endsley, 1996). However, controlling attention is a finite capacity (Warm, Parasuraman, & Matthews, 2008), which is vulnerable to aging (Craig & Salthouse, 2000), multitasking (Ophir, Nass, & Wagner, 2009), and stress (Kuhlmann, Piel, & Wolf, 2005). Despite rigorous selection procedures and continual task training in high-performance aviation, workers in such dynamic environments will always need methods to cultivate attentional skills to prevent attrition and future accidents.

One potential method of regulating attention that is currently drawing a substantial amount of interest worldwide is mindfulness training (MT; Richard, Lutz, & Davidson, 2014). The concept of mindfulness stems from Buddhist and meditative traditions and is now commonly defined as “paying attention in a particular way, on purpose, in the present moment, and nonjudgmentally” (Kabat-Zinn, 1994, p. 4). Based on neuropsychological research, Cahn and Polich (2006)

suggested that *attention* is the primary psychological domain that mediates and is affected by meditative practice. Studies have shown that MT leads to more efficient and flexible use of attention (Brown, Ryan, & Creswell, 2007; Slagter et al., 2007). From a conceptual and neural perspective, MT is thought to exert its effects not only by improving self-regulation of attention, but also through emotion regulation, body awareness, and bringing about a change in perspective on inner and outer experience (Hölzel et al., 2011). Bishop et al. (2004) suggested that mindfulness consists of two psychological components: self-regulation and an attitudinal component. Self-regulation involves the regulation of attention to maintain focus on immediate experience, including the ability to concentrate, move attention flexibly, and inhibit excess thinking or rumination. The second attitudinal component involves approaching inner and outer experiences with a curious, open, and accepting attitude, regardless of their valence and desirability. Theoretically, MT could lessen emotional bias in stimulus perception by facilitating nonevaluative contact with moment-to-moment experience (Brown et al., 2007), which results in an awareness of stimuli with fewer distortions and less reactivity related to emotional valence (Bishop et al., 2004). Studies have indeed revealed that MT alleviates anxiety and depression (Hofmann, Sawyer, Witt, & Oh, 2010), improves psychological well-being, and enhances stress-management skills (Chiesa & Serretti, 2009). Research investigating how MT is applicable to specially selected healthy populations preparing for peak performance is, however, limited.

One exception is a controlled study finding that 8 weeks of MT improved working memory in a group of U.S. Marine Corps reservists during a high-stress period prior to deployment to Afghanistan (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010). A few observational studies point to the beneficial effects of MT in elite athletes (Birrer, Rôthlin, & Morgan, 2012). Cultivating mindfulness is a lengthy process stretching over several years, commonly initiated in the West by attending a structured course, such as the 8-week Mindfulness-Based Stress Reduction (MBSR) program (Kabat-Zinn, 1994). Feasibility studies on high-performance groups conducting MT over an extended period with follow-up are also lacking. This study attempts to address this gap in the literature.

The aims of this study were to (a) investigate implementation and feasibility of a 1-year MT intervention in a military population of high-performance aviators, and (b) document changes in how they rated their own mental skills and symptoms of anxiety. Based on theory, we predicted that MT would lead to an increase in the pilots' self-rated levels of attention and arousal regulation. We further predicted that this would reduce symptoms of performance-related anxiety.

## METHODS

### Procedure

All available pilots and mission support personnel from a Norwegian F-16 combat aircraft squadron ( $n = 21$ ) were recruited and offered MT for 12 months. The participants completed questionnaires before and after the intervention. A psychologist administered a 30-min, semistructured, postintervention interview to provide more detailed feedback. Follow-up measures consisted of a mindfulness questionnaire together with written responses to a small number of open-ended questions about current experience and operational value of MT. We administered these by e-mail 12 and 24 months after the intervention. To ensure a representative sample, we

also administered preintervention questionnaires to pilots and mission support personnel available at a geographically separate national F-16 combat aircraft squadron ( $n = 8$ ). Participation was voluntary and participants provided written informed consent. The study was approved by the Norwegian Committee for Medical Research Ethics.

### Plenary Work

The participants received a 1-day introductory seminar followed by 14 3-hr plenary sessions every third week over a period of 12 months. The intervention followed the guidelines of the MBSR program (Kabat-Zinn, 1994); the basic structure of a plenary session consisted of 25% theoretical lectures and 75% guided MT. Theoretical lectures discussed why and how MT could be helpful. Guided practice consisted of three basic exercises used in MBSR programs:

1. *Yoga*: Simple movements such as standing, sitting, or lying down to practice being present and paying attention to the movements.
2. *Body scan*: Lying down while practicing awareness of one part of the body at a time.
3. *Sitting meditation*: Sitting on a chair while practicing being present with the breath and noticing thoughts, feelings, and bodily sensations.

The duration of each exercise varied from 20 to 45 min. At plenary sessions, participants were invited to share experiences and problems from their personal practice in discussion groups of two to four participants each. Each group then gave an informal summary presentation to the larger group. During six of the plenary sessions, an additional 1.5 hr was spent on being mindful during physical exercise because this was potentially an important future application of MT for the group. Participants were offered a 3-day retreat after 10 months.

### Individual Work

Participants received guided MT soundtracks to do personal practice outside of class for a minimum of 20 min three times per week. To increase the amount of MT, participants were encouraged to add mindfulness to everyday activities that they usually did on “autopilot,” such as working out, talking, listening, eating, walking, driving, and so on. The day after plenary sessions, the participants had a one-to-one session with an MT instructor, during which they could ask questions or discuss their practice. The main aim of the one-to-one sessions was to reinforce motivation to continue practice outside the classes. Participants received six inspirational text messages and eight e-mails with theoretical and inspirational information related to mindfulness and MT. To stimulate integration of MT into daily life, the participants’ respective partners were offered evening classes every third week during the first 6 months of the intervention and a comprehensive 10-hr mindfulness course after 8 months.

To make MT more readily acceptable to the population, the intervention was carefully designed to fit a high-performance military environment, copying some of the mental preparation activities used by elite athletes. One of the MT instructors, a military officer, facilitated program acceptance due to knowledge of the military community and culture. All MT instructors had a minimum of 10 years of meditative practice and were formally accredited mindfulness training instructors at the Scandinavian Centre for Awareness Training ([swww.scat.no](http://swww.scat.no)).

## Questionnaires

Demographic variables included gender, age, occupational role, marital status, number of children, and combat aviation experience. To assess mindfulness we used the Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). The FFMQ consists of 39 items rated on a 5-point Likert scale, and measures mindfulness on five interrelated subscales: observing, describing, acting with awareness, nonjudgmental responses to inner experience, and nonreactivity to inner experience. Preintervention mindfulness was assessed by administering a retrospective version of the FFMQ postintervention because it was considered that many of the items might have caused unwanted skepticism if presented prior to the intervention.

Self-perceived mental skills were assessed by the Norwegian Mental Skills Questionnaire for Athletes (NMS-42). The questionnaire consists of 42 self-statements rated on a 10-point Likert scale ranging from 1 (*I totally agree*) to 10 (*I totally disagree*), and includes six subscales: operational preparations, visualization, inner dialogue/confidence, arousal regulation, attention regulation, and goal setting. The questionnaire has been used for more than a decade by the Psychology Department at the Norwegian Olympic Training Center, and unpublished text shows a relationship between athletes' self-assessment and actual mental skills (Pensgaard, 2010). According to this report, a score of 3.6 or lower on a mental skill is evaluated as a well-mastered skill.

Performance-related anxiety was assessed by a Norwegian version of the Sport and Anxiety Scale (SAS; Smith, Smoll, & Schutz, 1990), validated in a Norwegian sample of athletes (Abrahamsen, Roberts, & Pensgaard, 2006). The SAS consists of 21 items rated on a 4-point Likert scale ranging from 0 (*not at all*) to 3 (*very much*). The subscales are somatic anxiety, worry, and concentration disruption. The participants received a questionnaire postintervention on which they were asked to rate the program, their own effort, and how useful they found the different elements of the training. The participants logged their personal formal MT practice throughout the project. The concentration disruption factor of the SAS was deleted because of low internal consistency. After removing Item 36 of the goal setting factor of the NMS-42, all other measures had internal consistency ranging from,  $\alpha = .70$  to  $.92$ .

## Statistical Analysis

Differences between pre- and postintervention assessments,  $p$  values, and effect sizes (Cohen's  $d$ ) were calculated using PASW Statistics 18 (Predictive Analytics Software). A Wilcoxon signed rank test was used to investigate postintervention changes. A  $p$  value of less than  $.05$  was considered statistically significant.

## RESULTS

### Descriptive Statistics

Approximately 80% of the participants were pilots; the remaining participants were from the mission support element of the squadron. Mean age was 33 years (range = 22–50 years). One

participant was female, 67% had one child or more, and 76% were either married or living with a partner who was employed part or full time. Mean work experience in combat aviation was 6 years (range = 1–13 years). Mean MT attendance was 9 plenary sessions (range = 6–13 sessions), 5 one-to-one sessions (range = 4–8 sessions), and 67% attended the 3-day retreat. Average personal practice outside class per week was 2.5 hr (range = 0.5–3 hr). No significant preintervention differences between the MT group and the other military combat aircraft squadron ( $n = 8$ ) were found on any of the measures.

### Adherence

Four participants left the squadron during the intervention period. Of the 17 participants who were tested at both at T1 and T2, 5 were excluded from the change analysis because they had attended fewer than six plenary sessions or had done no personal MT. All 17 participants were interviewed at T2. Twelve participants responded to the 8-month follow-up and 10 participants to the 2-year follow-up. We did not have contact details for 1 participant for the 2-year follow-up.

### Intervention Satisfaction

On a scale from 1 to 10, where a high score indicated satisfaction, the average score for the overall intervention was 8.4 ( $SD = 1.0$ ). On the same scale, participants scored body scan ( $M = 7.1$ ,  $SD = 2.7$ ) and sitting meditation ( $M = 7.3$ ,  $SD = 2.5$ ) as the most useful elements of the intervention. Yoga ( $M = 4.6$ ,  $SD = 1.1$ ) and reflection tasks ( $M = 5.7$ ,  $SD = 2.6$ ) were reported the least useful elements of the intervention. Eighty percent of the participants underscored the importance of a long-term (12-month) intervention period and the inclusion of partners. Participants reasoned they needed time to get used to the practice and experienced more benefit 6 to 8 months into the intervention. Participants also stated that without involvement of their partners in MT they would have found it difficult to keep up the practice beyond the first 3 months.

### Mindfulness

On the retrospective FFMQ postintervention, they were asked to rate whether they felt more or less different now than prior to the intervention (Figure 1). The results showed that the participants experienced a perceived increase on all the factors of mindfulness. The largest increases reported were in the factors measuring the ability to observe, act with awareness, and be nonreactive.

As can be seen in Table 1, the level of mindfulness remained higher throughout the whole 2 years of the follow-up period using the regular version of the FFMQ. Both the increases from the retrospective questionnaire and the persistent higher levels of mindfulness at follow up were confirmed by the interview data and the returned e-mails (Table 2).

### Perceived Mental Skills and Performance Anxiety

On a scale from 1 to 10, where a low score indicates being high on a mental skill, the combined group overall mean was  $<3.6$  on all the different mental skills prior to the intervention, except

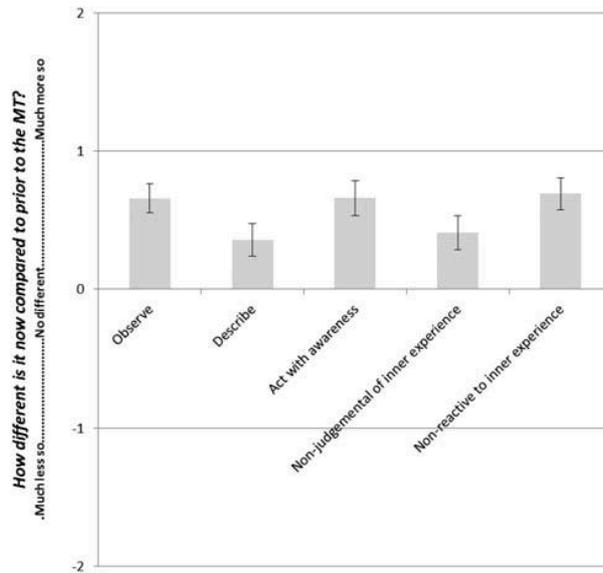


FIGURE 1 Mean change scores on the retrospective Five Facet Mindfulness Questionnaire from Time 1 to Time 2, with error bars showing standard error ( $n = 17$ ).

TABLE 1  
Mean Postintervention and Follow-Up Scores on the Five Factors of Mindfulness

Mindfulness (1–5)	<i>M</i> Score	<i>SEM</i>	<i>n</i>
Observe postintervention	3.17	.19	17
Observe 8-month follow-up	3.51	.17	12
Observe 24-month follow-up	3.49	.15	10
Describe postintervention	3.30	.19	17
Describe 8-month follow-up	3.38	.27	12
Describe 24-month follow-up	3.39	.21	10
Act with awareness postintervention	3.85	.16	17
Act with awareness 8-month follow-up	3.92	.14	12
Act with awareness 24-month follow-up	3.93	.11	10
Nonjudgmental postintervention	4.20	.18	17
Nonjudgmental 8-month follow-up	4.44	.15	12
Nonjudgmental 24-month follow-up	4.54	.16	10
Nonreactive postintervention	3.31	.18	17
Nonreactive 8-month follow-up	3.65	.17	12
Nonreactive 24-month follow-up	3.54	.19	10

for visualization and regulation of arousal level (Figure 2). Using a Wilcoxon signed-rank test, significant positive changes were found postintervention for perceived ability to regulate attention ( $p = .048$ ,  $d = .45$ ), regulate arousal ( $p = .003$ ,  $d = .84$ ), and in somatic anxiety ( $p = .033$ ,  $d = .38$ ). These results are displayed in Table 3.

TABLE 2  
Summary of the Interview Data

90% have one or more reports of becoming more mindful	<ul style="list-style-type: none"> <li>– I am able to notice the chaos of thoughts that sometimes occurs, without being stressed out anymore.</li> <li>– I don't worry much about the future anymore and have become better at just dealing with things when they occur.</li> <li>– The training has really "opened" my eyes.</li> </ul>
100% reported beneficial physiological effects	<ul style="list-style-type: none"> <li>– I have become more calm and relaxed.</li> <li>– MT has given me surplus energy.</li> <li>– I feel I use my energy more efficiently after doing MT.</li> </ul>
90% reported beneficial cognitive effects	<ul style="list-style-type: none"> <li>– I feel I can concentrate more easily, refocus, and get "in the zone" during flying and in daily life situations.</li> <li>– I feel I am better at planning and prioritizing.</li> <li>– I can clear my head more easily.</li> </ul>
80% reported beneficial effects on relations to themselves and others	<ul style="list-style-type: none"> <li>– I have become more aware of my thoughts, feelings, and people around me.</li> <li>– I feel good about myself and others more often.</li> <li>– I feel it has helped me to see people for who they really are.</li> <li>– I have become much closer to my family.</li> </ul>
50% report potential negative effects of MT	<ul style="list-style-type: none"> <li>– I experience both the good and the bad things in life with more intensity.</li> <li>– I experienced a lot of frustration along the way and felt things got worse before they improved.</li> <li>– It was no quick fix and it took me the whole year to really benefit from the practice.</li> </ul>
Examples of recurring items from the five subjects left out of the change analyses (based on a lack of participation or motivation to do the practice)	<ul style="list-style-type: none"> <li>– I became increasingly frustrated in the plenary sessions and it didn't get any better.</li> <li>– I felt bad and a bit guilty about not doing the practice.</li> <li>– The timing of the project was really bad. I had too much to do and think about at the time.</li> <li>– I did not get value for the time spent practicing.</li> <li>– I saw many had benefits from the training, but it wasn't doing anything for me.</li> <li>– I wish there had been more individualized practice directly related to our job.</li> </ul>

*Note.* MT = mindfulness training.

## Interviews

The interview data at T2 (Table 2) confirmed both the beneficial effects reported for regulation of attention and arousal, adding improvements in the quality of professional and private relationships. Three factors—lengthy plenary sessions, a lack of individualized practice, and motivation to do personal practice—were highlighted as the most important limitations of the intervention.

## Follow-Up

Eight months after the intervention, 11 out of 12 participants reported that MT had important and lasting beneficial effects for them; 2 years after the intervention 9 out of 10 participants still endorsed this statement. The same participants also reported that MT had made them more

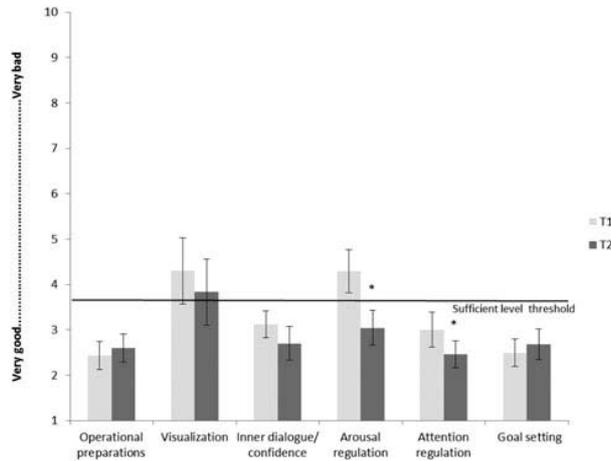


FIGURE 2 Mean scores on self-perceived mental skills at Time 1 and Time 2, with error bars showing standard error ( $n = 12$ ).

TABLE 3  
Mean Scores on Self-Perceived Mental Skills and Performance-Related Anxiety

	<i>M Score</i>	<i>SEM</i>	<i>t</i>	<i>df</i>	<i>p Value</i>	<i>Cohen's d</i>
Self-perceived mental skills (1–10)						
Operational prep T1	2.43	.31	-.54	11	.29	.26
Operational prep T2	2.60	.31				
Visualization T1	4.30	.73	.92	11	.13	.19
Visualization T2	3.83	.72				
Inner dialogue/confidence T1	3.12	.29	1.56	11	.13	.37
Inner dialogue/confidence T2	2.70	.37				
Arousal regulation T1	4.29	.47	3.62	11	.00*	.84
Arousal regulation T2	3.04	.39				
Concentration T1	3.00	.39	2.28	11	.05*	.45
Concentration T2	2.46	.30				
Goal-setting/motivation T1	2.49	.30	-.53	11	.62	.17
Goal-setting/motivation T2	2.68	.34				
Sport and Anxiety Scale (0–3)						
Anxiety T1	.39	.08	2.75	11	.03*	.38
Anxiety T2	.30	.08				
Worry T1	.51	.14	.84	11	.67	.21
Worry T2	.43	.10				

patient, present, and engaged in situations at work and life in general. At the 8-month follow-up, 9 out of 12 respondents reported doing weekly structured MT. Two years after the intervention, 8 out of 10 participants reported that they were still doing structured MT on a monthly basis. In the interviews and the follow-up e-mails, the participants reported that their preferred MT

methods were sitting meditation and body scans; none reported practicing yoga. Participants also reported having integrated MT into everyday life situations (e.g., being present in conversations, meetings, when doing physical training, or when playing with their kids). The participants gave various reasons for practicing mindfulness, ranging from general reasons (e.g., “I feel a better person, it gives me a better quality of life”), to more specific reasons (e.g., “It is a way to reduce stress or clear my head in order to make better decisions in a situation”).

### Operational Value

Three months after the end of the intervention, 10 participants took part in Operation Unified Protector (a NATO-led operation against Libya that took place in spring and summer 2011). Participants reported that the ability to establish a mindful state had specific benefit—the exact level of benefit varied among participants—for their personal performance on the planning, execution, and after-mission phases of this particular operation. This ability was particularly helpful for managing chaotic information and complex tasks, but was also found to be helpful for managing thoughts and feelings that arose from mission responsibilities. The participants emphasized that it was critical to the utility of the MT that they had done comprehensive MT prior to the operation. Five participants reported doing brief but structured MT during the operation.

## DISCUSSION

The aims of this study were to investigate (a) feasibility of a 1-year MT intervention in a military population of high-performance aviators, and (b) changes in perceived mental skills and performance-related anxiety as a result of MT. Supporting our hypothesis, we found that 12 months of MT increased subjective levels of attention and arousal regulation, decreasing already low levels of performance-related somatic anxiety. The data from the interviews and follow-up e-mails supported the statistical findings and indicated additional benefits for participants’ relationships. The data also identified potential limitations to MT in such populations, including the amount of time needed for practice, the extensive length of the intervention period, and a lack of individualized practice.

### Characteristics of the Study Population

The Norwegian Olympic Training Center uses a 3.6 threshold when evaluating whether a self-perceived mental skill is mastered well. Individual differences in levels of the various self-perceived mental skills assessed notwithstanding, this combat aviator sample already felt they had mastered the various mental skills prior to the intervention. This is not surprising given the rigorous selection and training procedures in the Norwegian Air Force. Two exceptions to this were structured visualizations and arousal regulation, which just fell short of the 3.6 threshold set for elite sports. Participants reported informally the importance of visualization and keeping calm before, during, and after aviation operations. However, they also reported a lack of systematic training and practice on these skills, which might explain why they rated their ability to do

structured visualization and arousal regulation slightly worse than the other skills at T1. It is difficult to judge whether the level of mindfulness measured in the current study is high or low for this particular population, as FFMQ has not previously been used with a comparable population.

Given that scores on many of the measures were high before the start of the intervention, the chances of ceiling effects were high. On the other hand, the study sample could be described as a peak-performance population, where even minor improvements could be of great importance.

### Change in Mindfulness

A general postintervention increase in the retrospective scores on all the factors of mindfulness (see Figure 1), together with the fact that the level of mindfulness remained higher throughout the 2 years of the follow-up period (see Table 1) provides evidence for the effectiveness of the intervention. This is consistent with theory suggesting that mindfulness is a multifaceted construct that develops synergistically over time (Hölzel et al., 2011). The largest changes were reported for the ability to observe, act with awareness, and be nonreactive toward inner sensations and experience. There could have been ceiling effects for ability to be nonjudgmental. The ability to be present, aware, and focused, as well as an enhanced ability to observe rather than automatically overreact are all highly valued skills in aviation. The fact that participants felt their ability to describe inner sensations to be less affected by the intervention might be related to cultural factors specific to this population. Describing emotions and sensations explicitly and in detail might not be common or valued in this population. Given the importance of paying attention to what is relevant in a situation, including fluctuations in inner state, strategies to improve the ability to describe inner experiences should be considered in the design of future interventions to improve efficiency.

### Change in Self-Perceived Mental Skills and Performance-Related Anxiety

The improvement in self-regulation of attention coincided with the increase in the ability to act aware and to observe inner and outer experiences. The interview data confirmed the positive effect MT seemed to have on the ability to be present, focused, and concentrated. This is in line with reports from meditators that regular MT helps them focus their attention for an extended period of time and makes them less distracted during MT and in everyday life (Barinaga, 2003). Given the reported operational value of MT together with the potential consequences of being unfocused or inattentive, in high-performance aviation, these findings imply a probable and important operational relevance. The results are also in line with the study of U.S. Army reservists exposed to extreme environments, in which MT was found to enhance attention regulation compared to a control condition (Jha et al., 2010). Despite the amount of attention training fighter aircraft personnel already accumulate by virtue of daily operations and missions, we were still able to detect improvements in this ability following the MT intervention. The reason for this could be that the specific strategies used in MT involve a change in strategy. Intentionally capturing the attention, forcing it back and striving to hold it in place, and judging oneself when focus is lost, could over time feel demanding. Letting the attention rest on an intended object, gently moving it, or bringing it back with no further cognitive processing might be more feasible. Because controlling attention is an energy-intensive, finite resource, such a change in strategy could involve

improvements in sustained attention as it requires greater present-centered awareness by default (Brewer et al., 2011).

The increase in arousal regulation together with the decrease in somatic anxiety could be related to the MT practice of openly observing and exposing oneself to inner and outer experiences with an attitude of curiosity and acceptance, rather than automatically overreacting. This practice could reduce the impact of thoughts and feelings tied to past and future events and thus over time change the response to potential stressors (Bishop et al., 2004). There are now numerous studies reporting positive effects of MT on stress relief (Chiesa & Serretti, 2009). However, it should be noted that some of the participants in this study reported increased rumination and unease during the initial phases of the intervention. Such fluctuations were not picked up by the questionnaires, but could be of vital importance to those responsible for MT interventions for two reasons. First, increased sensitivity to experience following MT has been shown to increase rumination and anxiety in clinical samples (Segal, Wittmann, & Teasdale, 2002) and there might be a similar effect in high-performance populations. However, the increase in exposure to inner and outer experiences is also an important adaptive process and one that plays a role in delivering the benefits of MT (Hölzel et al., 2011). Such experiences should therefore be considered a common effect of MT and should not be avoided; instead instructors should prepare participants to handle it when it arises.

Even though ceiling effects would be a plausible explanation for the lack of perceived improvements on many of the measures in this study, a lack of felt impact on some of the mental skills could also be related to the content of MT. In MT, one is encouraged not to manipulate, change, or engage in any thoughts, feelings, or bodily sensations. Instead MT involves a nonjudgmental observation of inner visualizations, dialogues, or goals as they appear in consciousness, endeavoring to let them go, and gently returning to the intended focus (e.g., the breath). Apart from an initial increase in awareness and the clarity of one's inner dialogues, images, and goals, one could probably not expect MT to further develop such mental skills in individuals who are already quite accomplished.

### Interviews

The interview data confirmed the quantitative findings and added important information on the potential preventive effects of MT. More specifically, participants reported that MT had improved the quality of their professional and private relationships. We know social belonging can be prophylactic against the negative effects of stress and their detrimental effect on performance (Rees & Freeman, 2012). This result is also in line with other theoretical and empirical evidence suggesting that being present with an open, accepting, and nonjudgmental attitude toward oneself helps to improve relationships with others (Yarnell & Neff, 2012). The increased awareness of inner experience following MT might not only relieve unnecessary affective reactions to stressors, but also allow participants to choose to reinforce enhancing rather than debilitating self-beliefs that, according to Bandura (1997), are the basis of an individual's efficacy.

Life in a combat aircraft squadron is characterized by a strict schedule and the time spent on MT could potentially be spent on other important tasks. Therefore, the length of time allocated to the plenary sessions created frustration among a few of the participants and should be regarded as an important potential limitation to this intervention. Similar limitations were found in a study testing cognitive adaptation training during military flight selection (Fornette et al., 2012).

### Implications for Practice

This study suggests that, if delivered with enough attention to work scheduling, a 12-month MT program could be an acceptable and useful intervention for a high-performance population. MT was found to have important general benefits for participants' professional and private lives, but to be of operational value we recommend that interventions be of a minimum of 6 to 8 months in duration. Motivation to complete the required personal practice seems to be critical to the effectiveness of MT, so interventions aimed at high-performing populations with strict schedules should be carefully tailored. Using squadron leaders as role models in MT between the plenary sessions in this study was important for compliance with the intervention and integration of MT into operational life.

Based on our feedback data, when time is limited an intervention based only on sitting meditation, body scan, and weekly discussion groups might be worthwhile. We also recommend introducing participants' partners to MT as life at home is a potential arena for realizing joint benefits of MT. This might have been especially important to the population in this study, as partners are often affected by the long hours and operational risks involved in military aviation.

### Strengths and Limitations

This is the first report on a lengthy MT intervention with a select group working in high-performance aviation during periods of regular activity. The combined length of the intervention and follow-up period should have been sufficient to elicit and detect some of the long-term perceived benefits of MT, which other studies have failed to capture.

There are a number of limitations to this study, including the lack of a control group, use of a small study sample, and exclusive use of self-report measures where one also had to be retrospective. The length of the intervention also made it difficult to separate the effects produced by MT from those attributable to other factors. Although representativeness was controlled in the preintervention, the study still only included personnel from a single squadron, who might have been extraordinary in some way. Thus, one should be careful not to generalize from the findings in this study.

Similar targeted MT interventions for high-performance groups should be tested further and validated with a controlled design incorporating direct measures of attention regulation or operational flight performance (e.g., visual attention and physiological responses to stress).

## CONCLUSIONS

This study demonstrated that the implementation of a 12-month MT program could be a feasible and acceptable method for implementation in a military combat aviation environment. A few potential limitations to MT interventions were uncovered, but could be overcome by careful planning. The study thus provides a starting point for implementing and measuring the effects of MT in elite individuals working in high-performance environments.

## ACKNOWLEDGMENTS

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## PAPER II

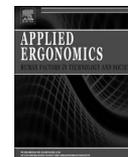
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## Action slips during whole-body vibration

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### ABSTRACT

Helicopter aircrew members engage in highly demanding cognitive tasks in an environment subject to whole-body vibration (WBV). Sometimes their actions may not be according to plan (e.g. action slips and lapses). This study used a Sustained Attention to Response Task (SART) to examine whether action slips were more frequent during exposure to WBV. Nineteen participants performed the SART in two blocks. In the WBV block participants were exposed to 17 Hz vertical WBV, which is typical of larger helicopter working environments. In the No-WBV block there was no WBV. There were more responses to the rare no-go digit 3 (i.e. action slips) in the WBV block, and participants responded faster in the WBV block. These results suggest that WBV influences response inhibition, and can induce impulsive responding. WBV may increase the likelihood of action slips, mainly due to failure of response inhibition.

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### 1. Introduction

We all experience occasions when we suddenly become aware that our minds have been 'absent' from an ongoing task and that we are no longer behaving according to plan, examples from everyday life include swiping an identification card instead of a credit card; throwing away the vegetables instead of the peelings; trying to drive off without releasing the hand brake (Reason, 1990; Reason and Mycielska, 1982). In almost all cases these commonplace slips and lapses cause us little more than momentary embarrassment. In aviation, however, the consequences of similar slips and lapses could be catastrophic. The difference lies not in the nature of the error, but in the extent to which circumstances affect the severity of the consequences.

According to an analysis of all European helicopter accidents between 2000 and 2005, pilot judgement and actions was the most common causative factor, and was involved in almost 70% of the accidents (European Helicopter Safety Team (EHST), 2010). Undesired Aircraft States (UAS) are flight-crew induced aircraft position or speed deviations, misapplication of flight controls or incorrect system configurations associated with a reduction in margins of safety. An inappropriately managed UAS may lead to an

incident/accident (EHST, 2014).

Reason and Mycielska (1982) summarized information on private aircraft accidents in which an error committed by a pilot was implicated, and concluded that the errors displayed many of the characteristics of absent-minded slips in that they involved apparently unintentional execution of well-established control actions, or omission of such actions. Such errors are important in many working environments. Specialists such as aircraft pilots will easily be able to imagine circumstances in which omitting to execute particular actions in the event of engine failure would have catastrophic consequences. The resemblance between these pilot errors and everyday absent-minded slips does not in itself constitute an explanation for these accidents but the underlying mechanism may be similar; as Reason and Mycielska (1982) put it '*the resemblance between these pilot errors and everyday absent-minded slips does suggest we could learn a good deal more about catastrophic errors from a closer scrutiny of action slips of our daily life*'. In addition, action slips provide important clues about the organization of human performance and the role of conscious attention in the guidance of action especially when sustained attention to action is required to execute a task successfully.

During operations a helicopter pilot has to maintain attention to ongoing tasks. Insufficient attention can result in slips of action when action sequences are triggered automatically, unintentionally and inappropriately. Such action slips tend to happen when attention to task is degraded through such factors as boredom,

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worry or division of attention among several tasks (Robertson et al., 1997). Sustained attention to ongoing tasks is important in preventing action slips; if attention is not sustained then absent-mindedness or mind-wandering is likely. Absent-mindedness or mind wandering in this context is not limited to daydreaming, it encompasses all conscious cognitive activity not focused on the immediate demands of the current task (Cheyne et al., 2011).

For the purposes of this study we have followed Robertson et al. (1997) in defining sustained attention as the ability to sustain mindful, conscious processing of stimuli whose repetitive, non-arousing qualities would otherwise lead to habituation and vulnerability to distraction. Robertson et al. (1997) developed the Sustained Attention to Response Task (SART) which requires a high level of continuous attention to responses and is sensitive to transitory reductions in attention or 'lapses' yet minimizes demands on other cognitive processes such as memory, planning and general intellectual effort. The SART is a go/no-go continuous performance task in which the no-go stimulus appears infrequently and is used as a measure of sustained attention, mind-wandering and the response inhibition element of executive function.

The primary SART measures of interest are errors of commission, errors of omission, and reaction times to frequent go-stimuli (Wilson et al., 2015). Helton and colleagues suggested that commission errors in the SART (i.e. a failure to withhold a response to a rare no-go stimulus) reflected failures of response inhibition while the omission error measure (i.e. a failure to respond to a go-stimulus) could be used as an indicator of sustained attention. Failures of sustained attention and response inhibition measured by the SART have been related to a number of real-world problems and psychological variables, including self-reported everyday failures of attention and attention-related cognitive errors (Cheyne et al., 2006; Manly et al., 1999; Robertson et al., 1997; Smilek et al., 2010; Wilson et al., 2015).

Whole-body vibration (WBV) is one of the more distinctive features of the helicopter working environment. The frequency and intensity of vibration to which the helicopter aircrew is subjected depend on the aircraft type, weather and flight profile (Kåsin et al., 2011). In every helicopter, peak WBV is related to the blade pass frequency, which varies normally between 15 and 24 Hz according to rotor velocity (3–7 revolutions per second) and number of rotor-blades (Kåsin et al., 2011).

WBV has an impact on performance of various tasks involving vision, motor activity and information processing (Conway et al., 2007; Griffin, 1990; Hopcroft and Skinner, 2005; Mansfield, 2005). The effects of WBV may be attributable to the direct effects of WBV on input processes (such as the collection of information via the various senses, particularly vision) and output processes (such as task-related responses in various modalities, usually manual responses). Indirect effects on motivation, mood and arousal may moderate the direct effects of WBV. The negative impact of WBV can be seen in many work environments but is perhaps most significant in those that require the concomitant use of both transportation and information systems (Conway et al., 2007). Operator performance in aviation or land-based vehicle operations is consistently affected by WBV (Mansfield, 2005).

Conway et al. (2007) conducted a meta-analysis of empirical studies assessing the influence of WBV on human performance; they showed that WBV generally caused a decrement in performance. The disruptive effects of WBV were related to the type of task being performed. The impact was greatest on perceptual tasks such as vigilance or target detection tasks. There was also a negative impact on continuous and discrete fine motor tasks (such as tracking and switching tasks) and on cognitive performance. The impact of WBV was also related to the type of outcome investigated; accuracy of response was degraded more than speed of

response.

Newell and Mansfield (2008) investigated effects of WBV and sitting posture on performance of a four-choice reaction time task and perceived workload. They revealed that the task performance was degraded irrespective of sitting postures during 1–20 Hz random WBV with an unweighted magnitude of  $1.4 \text{ m/s}^2$  in the x-direction (i.e. fore-and-aft direction) and  $1.1 \text{ m/s}^2$  in the z-direction (i.e. vertical direction). Participants' workload measured by the NASA-Task Load Index (NASA-TLX) also increased during the WBV. Interestingly, Newell and Mansfield found that the performance decrements during WBV were associated with increased perceived workload.

Although previous research has examined whether or how performance is degraded, it is not clear why this happens. This paper focuses on the mechanism underlying WBV effects, more specifically on information processing (i.e. perceptual, cognitive and response processes). There has been much less research on the impact of WBV on higher cognitive processes rather than health and discomfort, in spite of its prevalence in certain occupational contexts.

The purpose of this study was to examine how WBV at frequencies likely to be experienced in helicopter working environments influenced sustained attention. We hypothesized that WBV would increase the probability of failure in sustained attention. If failure of sustained attention is more likely during exposure to WBV one would expect a higher frequency of errors of commission (i.e. action slips), errors of omission (i.e. lapses) and faster response times during exposure to WBV than when WBV is absent.

The data presented here is part of a larger study of the effects of WBV and hypoxia on control of goal-directed and stimulus-driven attention. The study was performed in a hypobaric chamber. The results in hypoxic conditions will be reported in a separate paper. The experiments were conducted at the Institute of Aviation Medicine, Oslo, Norway.

## 2. Material and methods

### 2.1. Participants

Nineteen healthy volunteers (10 women; 9 men) with a mean age of 22.8 years ( $SD = 4.4$ ) participated in this study. All participants had normal or corrected-to-normal vision. All participants gave written informed consent before taking part and the study was approved by the Regional Committee for Medical and Health Research Ethics, Oslo, Norway.

All participants were elite orienteering runners. In order to reduce the effects of workload, we capitalized on a close cooperation with Norwegian elite athlete organizations and gained access to 19 elite runners in orienteering competing at a national level. The athletes were recruited via the national coaches. Orienteering is a highly cognitive sport and these athletes were highly trained in carrying out information processing tasks under environmental stress and could be expected to adapt readily to environmental changes, similar to helicopter pilots.

### 2.2. Apparatus

The stimuli were presented on a 27-inch LCD display (Samsung SyncMaster SA350) located at eye level, keeping the distance to the required 64 cm from participants in order to get the correct visual angle of stimuli. The timing of the events, generation of stimuli and recording of reaction times were controlled by a laptop computer connected to the LCD running SuperLab 4.0 software (Cedrus Corporation, San Pedro, California, U.S.).

Vibration was generated using an electrodynamic vibrator (LDS

Model 725 LIN-E-AIR, Ling Dynamic System Ltd., Royston, Herts., UK); a chair with a high backrest and a footrest was mounted on the vibrator (see Hansen et al., 2012). The vibrator was powered by a solid state Modular Power Amplifier (LDS MPA 1, Ling Dynamic Systems Ltd.) situated outside the hypobaric chamber. Vibration frequency and acceleration were monitored using a seat pad with accelerometers placed along three axes (Endevco type 2560, Brüel & Kjær, Nærum, Denmark). The pad was connected to a front end (type 3560C, Brüel & Kjær, Denmark). Vibration data were processed and monitored in real time using specialized software (Pulse Labshop 12.1, Brüel & Kjær). WBV in the vertical axis (z-axis) was 17 Hz with an unweighted magnitude of 1.0 m/s<sup>2</sup> RMS throughout the experiment.

Fig. 1 shows the experimental setup.

### 2.3. Task

The SART was used in this experiment. Single digits (1–9) were presented centrally on a 27-inch LCD; each digit was presented 25 times giving a total of 225 stimulus presentations during a 4.3 min period. Each stimulus presentation consisted of a 250 ms

presentation of the digit followed by a 900 ms presentation of the mask (an encircled X). Digit presentation was regularly paced, with an onset-to-onset interval of 1150 ms. Both digits and mask were white against a black background. Participants responded to the go digits (i.e. 1, 2, and 4–9) with a key press on a handheld response device; when the no-go digit (3) was presented they were required to withhold this response. The 25 no-go trials were randomly distributed among the 225 trials. The 225 trials were presented in a single continuous block. Participants responded by pressing the key on the response device with the thumb of their dominant hand. Digits were presented in one of five randomly assigned font sizes (48-, 72-, 94-, 100- and 120-point size; Symbol font) following the procedure described by Robertson et al. (1997). Participants were instructed that speed and accuracy were equally important.

### 2.4. Procedure

Participants were tested individually. After completing a practice session consisting of 18 trials, two of which were no-go trials (i.e. digit 3) participants walked into the experimental chamber and sat in the chair mounted on the vibrator. Participants used noise cancelling headphones (Bose A20, Bose Corporation, Massachusetts, U.S.) throughout the experiment in order to avoid confounding noise effects. Participants performed two SART blocks, one without WBV (No-WBV) and one with WBV. Before the WBV block participants were exposed to the WBV for one minute to allow them to adapt to the situation. Ten participants performed the No-WBV block first; the remaining 9 started with the WBV block. Block presentation order was pseudo-randomly determined.

At the end of each block participants reported the mental demand (How do you rate the mental demand required to complete the task?) and effort (How do you rate the effort required to complete the task?) using subscales of the NASA-TLX which is a multi-dimensional scale designed to obtain estimates of workload (Hart and Staveland, 1988). Responses were given on a twenty-point scale. At the end of the WBV block participants also reported perceived discomfort associated with exposure to WBV using a five-point scale (1, not uncomfortable; 2, a little uncomfortable; 3, fairly uncomfortable; 4, uncomfortable; 5, very uncomfortable).

### 2.5. Data analysis

Four scores were derived from the SART data: number of errors of commission (responses to the rare no-go digit), number of errors of omission (failures to respond to go digits), mean reaction time (RT), and a coefficient of variance (Cheyne et al., 2009). Mean RTs were calculated from the number of go-trials on which the RT was over 100 ms. The coefficient of variance (RTCV) was calculated for all go-trials with a RT over 100 ms. It was calculated by dividing standard deviation in RTs by mean RT for each participant, and provided a measure of variability which was independent of differences in mean RT.

To examine the primary hypotheses, errors of commission, errors of omission, RT and RTCV in the WBV block were compared with those of the No-WBV block. Second, the relationships among the SART variables were investigated to understand the mechanism underlying errors of commission. Thirdly, mental demand and effort were compared between the WBV block and the No-WBV block to examine the effect of WBV on subjective workload.

Statistical analyses were performed using SPSS (SPSS version 22.0 for Windows, IBM Corporation). Considering the sample size of the current research, we statistically tested the differences in the SART variables between the WBV block and the No-WBV block by using Wilcoxon signed-rank test. Given the problem of multiplicity, the FDR controlling method (Benjamini and Hochberg, 1995) was

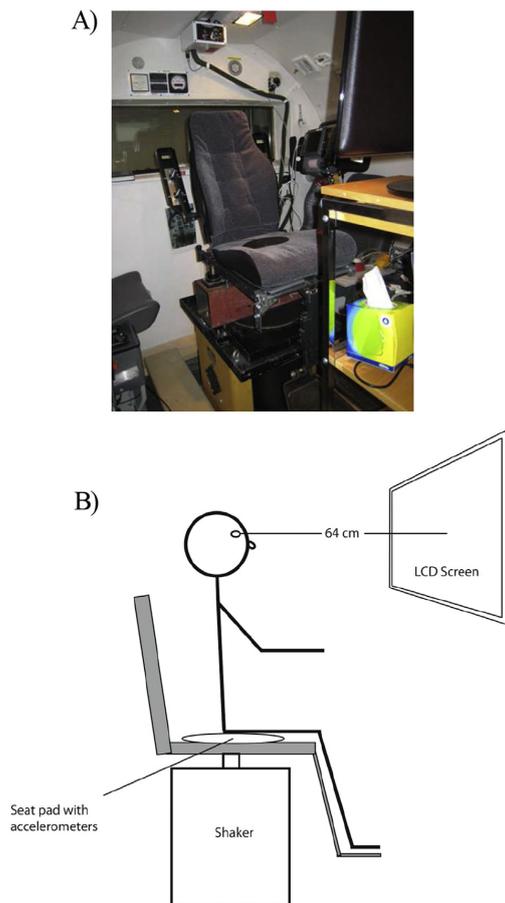


Fig. 1. The experimental setup A) a picture of the experimental settings. B) Position of the participant during the SART.

used to control the false discovery rate (FDR) at .20. In line with the previous studies (e.g. Cheyne et al., 2009; Wilson et al., 2015), Pearson product–moment correlations were used to assess relationships between variables. Two-tailed  $p$ -values and effect sizes ( $r$ ) were reported.

### 3. Results

#### 3.1. SART performance

Errors of commission, errors of omission, RT and RTCV in each block are shown in Fig. 2. Errors of commission were found more frequently in the WBV block than in the No-WBV block ( $Z = -2.08$ ,  $p = .037$ ,  $r = -.34$ ). The number of errors of omission in the WBV block was similar with that of the No-WBV block ( $Z = -1.22$ ,  $p = .223$ ,  $r = -.20$ ). Mean RT was shorter in the WBV block than in the No-WBV block ( $Z = -2.13$ ,  $p = .033$ ,  $r = -.35$ ). RTCV was similar in the WBV block and the No-WBV block ( $Z = -.20$ ,  $p = .841$ ,  $r = -.03$ ).

Pearson product–moment correlations among the SART variables are shown in Table 1.

In the No-WBV block, errors of commission were highly

correlated with mean RT ( $r = -.875$ ,  $p < .001$ ). Errors of omission were highly correlated with RTCV ( $r = .745$ ,  $p < .001$ ). There was a negative correlation between mean RT and RTCV ( $r = -.588$ ,  $p = .008$ ).

In the WBV block, the number of errors of commission was highly correlated with mean RT ( $r = -.721$ ,  $p < .001$ ) and RTCV ( $r = .503$ ,  $p = .028$ ). Errors of omission was correlated with RTCV ( $r = .605$ ,  $p = .006$ ). There was a negative correlation between mean RT and RTCV ( $r = -.790$ ,  $p < .001$ ). None of the SART measures correlated significantly with subjective ratings of mental demand, effort or discomfort.

Mean RT was correlated with errors of commission and RTCV, so partial correlations were calculated (Table 2) to control for the influence of mean RT (i.e. control for the speed–accuracy trade-off). In the No-WBV block, errors of commission were highly correlated with RTCV even after controlling for mean RT ( $r = -.559$ ,  $p = .016$ ). RTCV was positively correlated with errors of omission ( $r = .675$ ,  $p = .002$ ). In the WBV block, errors of commission were not correlated with other SART variables after controlling for mean RT, although there was a significant correlation between errors of omission and RTCV ( $r = .629$ ,  $p = .005$ ).

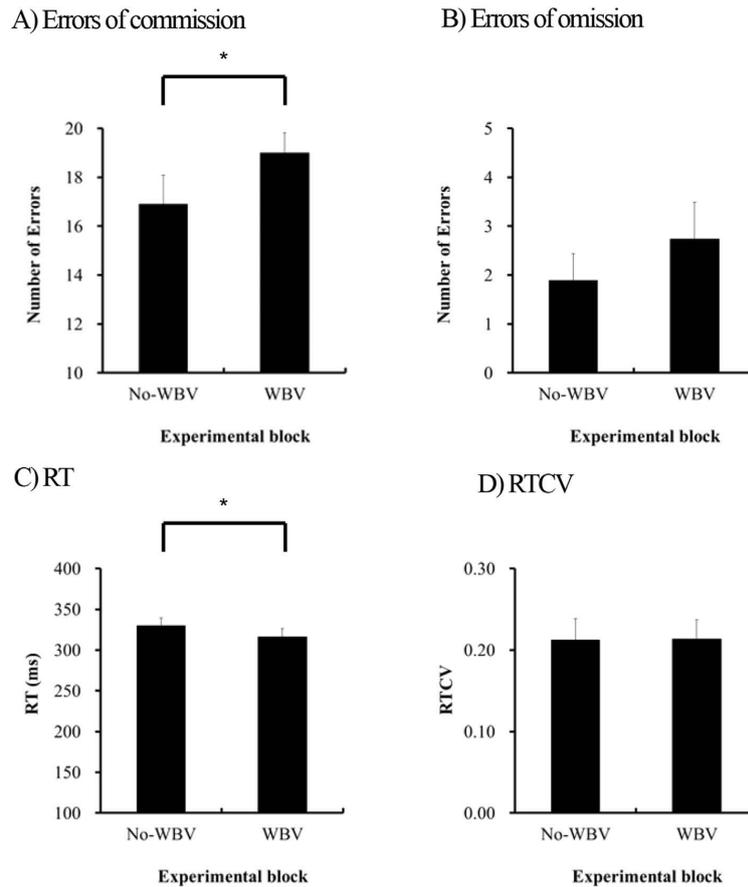


Fig. 2. The SART performance ( $N = 19$ ) A) errors of commission. B) errors of omission. C) reaction time (RT). D) Coefficient of variance (RTCV). Error bars indicate +1 standard error of the mean. \*indicates a significant difference between the blocks.

**Table 1**  
Correlation coefficients (*r*) between variables in the No-WBV block and the WBV block.

	SART variables				Subjective ratings	
	Errors of commission	Errors of omission	Mean RT	RTCV	Mental demand	Effort
<b>No-WBV block</b>						
<i>SART variables</i>						
Errors of commission	–	.185	–.875**	.296	.014	.082
Errors of omission		–	–.428	.745**	.235	.320
Mean RT			–	–.588**	–.204	–.315
RTCV				–	.280	.311
<i>Subjective ratings</i>						
Mental demand					–	.760**
Effort						–
<b>WBV block</b>						
<i>SART variables</i>						
Errors of commission	–	.110	–.721**	.503*	–.048	–.088
Errors of omission		–	–.301	.605**	.157	.212
Mean RT			–	–.790**	–.257	–.142
RTCV				–	.327	.293
<i>Subjective ratings</i>						
Mental demand					–	.740**
Effort						–
Discomfort	.075	–.139	.154	–.172	.214	.398

Note: \**p* < .05, \*\**p* < .01.

**Table 2**  
Partial correlation coefficients between SART variables in the No-WBV block and the WBV block.

	Errors of commission	Errors of omission	RTCV
<b>No-WBV block</b>			
Errors of commission	–	–.434	–.559*
Errors of omission		–	.675**
RTCV			–
<b>WBV block</b>			
Errors of commission	–	–.161	–.156
Errors of omission		–	.629**
RTCV			–

Note: \**p* < .05, \*\**p* < .01.

### 3.2. Mental demand, effort and discomfort

Participants' ratings for the mental demand, effort and discomfort are reported in Table 3. Ratings of mental demand and effort were not significantly different between the two experimental blocks (mental demand:  $Z = -1.63$ ,  $p = .103$ ,  $r = -.27$ ; effort:  $Z = -1.67$ ,  $p = .095$ ,  $r = -.27$ ).

Ratings of discomfort associated with WBV ranged from 1 (not uncomfortable) to 4 (uncomfortable). Discomfort was not associated with ratings of mental demand and effort, but there was a correlation between ratings of mental demand and effort (Table 1).

## 4. Discussion

This study was designed to evaluate sustained attention and response inhibition during WBV using the SART, which provides a measure of sustained attention, mind-wandering and response inhibition. Errors of commission, errors of omission, mean RT and RTCV were compared across two experimental blocks (the No-WBV block vs. the WBV block); the mental demand and effort required to

**Table 3**  
Subjective rating scores: mental demand, effort and discomfort.

	No-WBV	WBV
Mental demand (SD)	12.5 (3.8)	13.1 (3.6)
Effort (SD)	13.2 (4.1)	13.9 (3.6)
Discomfort (SD)	–	2.4 (0.8)

carry out the SART under these two conditions were also compared. The results revealed significant effects of WBV on SART performance.

### 4.1. SART performance

Errors of commission on the SART increased during exposure to WBV. Errors of commission are usually considered analogous to real-world action slips (Cheyne et al., 2009) suggesting that WBV with the parameters used in this experiment may cause an increase in the frequency of action slips. Given that there were more errors of commission under WBV, one might expect that responses would be faster (indicating a speed-accuracy trade-off). Speed-accuracy trade-offs on the SART have been reported previously (e.g. Cheyne et al., 2006; Cheyne et al., 2009; Helton, 2009; Robertson et al., 1997; Seli et al., 2013; Wilson et al., 2015). We found that mean RT was shorter in the WBV block than the No-WBV block. However, errors of omission in the WBV block did not significantly differ from those of the No-WBV block, supporting the notion that WBV decreases response inhibition, rather than sustained attention.

In this study, errors of commission were negatively correlated with mean RT in both the No-WBV and the WBV blocks, suggesting a speed-accuracy trade-off. To control for the effects of a speed-accuracy trade-off, partial correlation coefficients were calculated for each experimental block. In the No-WBV block, errors of commission were negatively correlated with RTCV after controlling for mean RT, suggesting that errors of commission and RTCV are causally related, as Cheyne et al. (2009) suggested. It is also interesting to note that after controlling for mean RT errors of commission in the WBV block were not correlated with other SART measures. This implies that RT mediates the relationship between errors of commission and the other SART variables. Thus, shorter RTs during WBV may be responsible for much of the increase in errors of commission, that is, the increase in action slips. In other words, WBV may cause faster responding thus producing more errors of commission on the SART.

### 4.2. Mental demand, effort and discomfort

The mental demand and the effort required to perform the SART

was not different between no-vibration and vibration, in this elite athlete sample. This was contrary to Newell and Mansfield (2008) study using students. The reason for this may be that the elite orienteering runners in our study were accustomed to perform information processing tasks under environmental stress, and might not feel disturbed or affected by the vibration. However, compared to previous research, the perceived mental demand and effort to complete and maintain performance levels of the SART in No-WBV block were higher in the current study. This may be due to the task demand of the SART. For instance, Newell and Mansfield (2008) used a four-choice reaction time task which arguably is a less demanding task compared to a go/no-go task.

#### 4.3. Action slips under WBV

There were more action slips (i.e. errors of commission in the SART) under WBV primarily due to the shortening of mean RT. However, there are some possible explanations as to why mean RT became shorter during WBV. The recent suggestion that the SART is a compound task tapping both response inhibition and sustained attention means that the majority of errors of commission may actually be due to failure of response inhibition rather than failure of sustained attention (Carter et al., 2013; Helton et al., 2009; O'Connell et al., 2009; Wilson et al., 2015). Inhibitory control is an important executive function, allowing us to suppress, interrupt or delay an activated action (Aron et al., 2004; Logan and Cowan, 1984). The SART is sensitive to impulsive responding (Helton, 2009; Sakai et al., 2013) and the higher error rates in the WBV block may reflect more impulsive responding during WBV.

An increase in the frequency of errors of commission under WBV could be interpreted as an indication that paying more attention to visual stimuli enhances response speed at the expense of accuracy, thus resulting in more failures of reactive inhibitory control on no-go trials (Helton, 2009; Sakai et al., 2013). Proactive inhibitory control functions as a brake on responding when future events are uncertain i.e. it enables slow but accurate responding (Aron, 2011; Sakai et al., 2013). If proactive inhibitory control is compromised, responses can be triggered automatically by external events regardless of their implications. Thus, failures of both reactive and proactive inhibitory control are possible causes of the shorter mean RT on go-trials during WBV.

#### 4.4. Limitations

This study has some limitations. The WBV used in this study was unidirectional (vertical axis) and single frequency (17 Hz). Seventeen Hz is the dominant WBV frequency in many helicopters (Kåsin et al., 2011) but any helicopter working environment may have a different dominant frequency, and WBV is likely to be made up of a wider spectrum of frequencies in three orthogonal axes. There is also both inter- and intra-individual variability in resonant frequencies in the human body. Some caution must therefore be exercised in extrapolating our results to other vibration environments. The blade passing frequency for most helicopters is normally between 15 and 24 Hz. We could have chosen another frequency within this limited range, but we wouldn't expect any major differences in the results. By choosing a frequency closer to the typical resonant frequency of the human body (5 Hz) the impact of the exposure might be different (Griffin, 1990). However, such an experiment would have a lower validity for the working environment of helicopters.

These experiments were conducted under specific laboratory conditions and the participants received only brief training on the task investigated. It is uncertain whether the same pattern of errors and similar trends in RTs would be observed in helicopter aircrew

performing a real life task, for which they have received special training and are highly experienced. However, by recruiting elite runners in orienteering competing at a national level, we could capture the effect of WBV on the SART performance excluding the possible effects of perceived workload during the task. Therefore, our findings should also be relevant for helicopter aircrew.

In this study, the duration of vibration was short, and it is possible that the decreased RT would not have been sustainable over a longer time period. During prolonged exposure to WBV we might also have been able to detect effects on perceived mental demand and effort required to perform the task, as well as discomfort associated with WBV.

We cannot rule out the effects of biomechanical factors. The WBV could be causing a tonic reflex response, which means that the muscle is pre-primed and can activate a response more quickly. Due to the use of a handheld response device separated from the chair, we believe such biomechanical effects were of minor importance in the current experiment.

Further research is required to improve understanding of how WBV affects performance on cognitive tasks sensitive to sustained attention and response inhibition in helicopter working environments.

## 5. Conclusion

Our findings suggest that exposure to WBV at a frequency which is common in helicopter working environments increases the probability of committing errors of commission on the SART (i.e. action slips). The reduction in response latencies to incoming stimuli under WBV may be the main cause of the increase in the frequency of action slips, reflecting impulsiveness and failures of response inhibition.

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## PAPER III

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## Impact of Mindfulness Training on Physiological Measures of Stress and Objective Measures of Attention Control in a Military Helicopter Unit

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## Impact of Mindfulness Training on Physiological Measures of Stress and Objective Measures of Attention Control in a Military Helicopter Unit

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**Objective:** This study sought to determine if mindfulness training (MT) has a measurable impact on stress and attentional control as measured by objective physiological and psychological means.

**Background:** Periods of persistent, intensive work demands are known to compromise recovery and attentional capacity. The effects of 4-month MT on salivary cortisol and performance on 2 computer-based cognitive tasks were tested on a military helicopter unit exposed to a prolonged period of high workload.

**Methods:** MT participants were compared to a wait list control group on levels of saliva cortisol and performance on a go–no go test and a test of stimulus-driven attentional capture. Participants also reported mental demands on the go–no go test, time of wakeup, sleep duration, quality of sleep, outcome expectancies, physical activity level, self-perceived mindfulness, and symptoms of depression and anxiety.

**Results:** The results from a mixed between–within analysis revealed that the MT participants compared to the control group had a larger pre to post increase in high- and low-cortisol slopes, and decrease in perceived mental demand imposed by the go–no go test.

**Conclusion:** MT alleviates some of the physiological stress response and the subjective mental demands of challenging tasks in a military helicopter unit during a period of high workload.

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Human beings have a capacity to adapt to and endure prolonged periods of high workloads. However, repeated, excessive, or prolonged energy mobilization without sufficient rest might contribute to physical disease, increased mortality, reduced well-being, and deficits in executive functioning in normal populations (Cohen, Janicki-Deverts, & Miller, 2007; Liston, McEwen, & Casey, 2009; McEwen, 1998) and in military cohorts (Jha et al., 2015; Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Schnurr, Lunney, Bovin, & Marx, 2009; Vasterling et al., 2006). Therefore, there is a growing concern about the long-term effects of physical and psychological demands combined with prolonged high workloads associated with military deployments. A report by the Rand Corporation states that deployments are longer and more frequent than in conflicts such as the Vietnam and Persian Gulf wars and that there are shorter intervals between deployments (Tanielian & Jaycox, 2008). Under these circumstances, one should continually strive to minimize the burden on the personnel, knowing that there will still be times when little can be done to reduce workload involved in mission completion.

It is far from clear which strategies work best to conserve energy and maximize recovery when reduction in external workload is not an option. Mindfulness training (MT) is a psychological intervention that is suggested to improve situational awareness (Bishop et al., 2004), reduce systemic arousal, and increase parasympathetic activity without compromising alertness (Ditto, Eclache, & Goldman, 2006; Tang, Holzel, & Posner, 2015; Tang et al., 2009). A capacity to remain both calm and alert is not a combination humans have naturally inherited through the millennia. Therefore, MT has been suggested to be of particular value for several groups striving for excellence in taxing environments (Fornette et al., 2012; Jha et al., 2010; Sappington & Longshore, 2015).

### MINDFULNESS TRAINING AND THE STRESS RESPONSE

Neurological research suggests that the stress-reducing effects of MT result from adaptation, consolidation, and attribution processes (Hölzel et al., 2011). People often react automatically to challenges and find ways to distract or suppress unwanted experiences. These mental strategies are strenuous, they can increase parasympathetic nervous system activity, and they can make us more vulnerable to environmental stressors (Gross, 2002). By contrast, MT encourages one to adopt a state of restful alertness to present-moment experience, stressful or not, making no effort to control thoughts or feelings that might emerge (Bishop et al., 2004).

This shift in strategy could be stress-reducing and less demanding in itself, because by default it involves a more present-centered awareness (Brewer et al., 2011). Over time this strategy is thought to improve people's ability to tolerate and cope with negative emotional states, by extinguishing activation responses and avoidance behaviors previously elicited by these stimuli (Baer, 2003). The process could be further stimulated by a change in the way one perceives a situation, which is known to be of importance to adjust or habituate to stressors (Lazarus & Folkman, 1984). Another possibility is that the automaticity of physiological activation caused by a stressor is short-circuited when an individual believes he or she can cope with the stressor, a so-called positive response outcome expectancy (PROE; Ursin & Eriksen, 2004).

### CORTISOL AS A BIOLOGICAL MARKER OF RECOVERY

Cortisol, the end product of the hypothalamic–pituitary–adrenal (HPA) axis, is one of the biological mediators providing energy to cope with daily demands, and is regarded as a reliable marker of the physiological stress response (Pruessner et al., 1997). The cortisol hormone triggers the release of glucose in the body and is an important part of energy mobilization and expenditure, but also the wear and tear of the body. Cortisol levels are subject to short-term fluctuations caused by acute stressors, and a slower 24-hr cortisol cycle, closely related to metabolic rate. Cortisol levels are highest during the second half of the night, with a peak level in the morning after awakening, and decline throughout the day with the nadir around midnight (McEwen, 1998; Wilhelm, Born, Kudielka, Schlotz, & Wüst, 2007). Acute exposure to a taxing environment would normally lead to higher secretion of cortisol in healthy individuals, but repeated energy mobilization without sufficient recovery depletes bodily resources and could lead to exhaustion and lower cortisol secretion. Prolonged periods of high demands have therefore been associated with lower morning cortisol levels, a blunted cortisol awakening response (CAR), and higher evening cortisol values (Kristenson et al., 2012; O’Leary, O’Neill, & Dockray, 2015; Schlotz, Hellhammer, Schulz, & Stone, 2004). Thus, the CAR and cortisol slopes from morning to evening might all be valuable indicators of the capacity to respond to or recover from stressful stimulation. CAR is a measure of the responsiveness to wake-up of awakening; it is calculated as the difference between cortisol levels at wake-up and 30 min after wake-up. High slope is a measure of the maximal dynamic, because it is calculated as the difference between the peak cortisol values 30 min after wake-up to bedtime. Low slope is calculated from the wake-up values to bedtime and therefore excludes the extreme value related to the wake-up response (Kristenson et al., 2012). Moreover, higher CAR scores and steeper slopes could indicate normal metabolism and sufficient recovery after a stressful stimulus, whereas lower CAR and blunted slopes could indicate a lack of recovery.

### THE STRESS-BUFFERING EFFECTS OF MT

Stress-buffering effects of MT have been found in highly stressed community workers (Nyklicěk, Mommersteeg, Van Beugen, Ramakers, & Van Boxtel, 2013) and nurses (Klatt, Steinberg, & Duchemin, 2015), and patient populations exposed to prolonged stressors (e.g., patients with HIV, psoriasis, pain, or chronic inflammation; Cohen et al., 2007). In a study by our group, we also found that 12 months of MT improved self-reported mindfulness, attentional control, and arousal regulation in a high-performance combat aircraft unit (Meland, Fonne, Wagstaff, & Pensgaard, 2015). These studies are consistent with the proposed theory that MT has potential restorative effects on individuals exposed to prolonged periods of high demands. There is a lack of controlled studies testing the effects of MT using objective measures of stress and attentional control, especially during prolonged periods of high workloads.

The aim of this study was therefore to test the restorative effect of MT in a healthy high-performance cohort using objective measures of the stress response, recovery, and attentional control. We capitalized on the rare opportunity afforded by access to personnel at two military helicopter units during a prolonged period of high workload. One group received 4 months of MT, and the other served as a wait list control group. We expected that the MT would effectively increase

self-perceived mindfulness. Due to the cumulative fatigue induced by the personnel's prolonged exposure to high workload at pretest, we hypothesized that the restorative effects of MT would produce an increase in CAR and higher wake-up values while evening values remained low, thereby producing steeper cortisol slopes. Based on the proposed change in attentional strategy, we expected that the MT group would commit fewer errors on the go–no go test and increased sensitivity to the target on attentional capture test. We also expected that the MT group would find the go–no go test less demanding to perform after the intervention, compared to the control group. As the sample was comprised exclusively of selected high-performing individuals we did not expect to find significant changes in already low levels of anxiety, worry, or depression.

## METHOD

### Experimental Design

A pretest and posttest with nonrandom assignment were used to investigate the effects of MT on stress reduction and attentional control. The choice of intervention group was based on the geographical availability of MT instructors delivering the intervention. Data from questionnaires, saliva samples, and scores on computerized tests were collected before and after the intervention period.

### Variables

Group affiliation was the single independent variable in this experiment, and there were a number of dependent variables, including levels of saliva cortisol, measures of performance on a go–no go test, and a test of stimulus-driven attentional capture test. We also measured self-reported mindfulness, mental demand on the go–no go test, anxiety, depression, and daily positive response outcome expectancies. Length and quality of sleep, amount of physical activity, and demographics were also documented.

#### *Cortisol*

Three measures of cortisol were derived from the data. The CAR was calculated by subtracting the 30 min postwaking value from the waking value. The high and low slopes were calculated by subtracting the bedtime value from the waking value and 30 min postwaking values, respectively (Kristenson et al., 2012)

#### *Sustained Attention to Respond Task*

The Sustained Attention to Respond Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) is sensitive to transitory reductions in attention and the response inhibition element of executive function, yet minimizes demands on other cognitive processes such as memory, planning, and general intellectual effort. Two scores were derived from the SART: number of errors of commission (responses to the rare no-go digit, 3) and reaction times (RTs) to frequent go stimuli.

### *Attentional Capture Task*

To reduce the burden on participants we designed a shortened version of the Attentional Capture Task (ACT; Theeuwes & Chen, 2005) based on a previous experiment (not published). The ACT measures the vulnerability for automatic and reflexive attentional capture. The attentional capture is created by a task-irrelevant peripheral stimulus (i.e., a red blink) that flashes for 60 msec equally often at one of the six positions prior to the target appearance. The attentional capture effect is measured in five conditions according to the presence and position of the distractor: (a) no distractor: no red-blink; (b) cued condition: red blink on target position; (c) Distance 1: red blink closest to target; (d) Distance 2: red blink second closest to target; and (e) Distance 3: farthest away from the target. The task took 15 min to complete. Two scores were derived from the ACT on all five conditions: mean RTs and sensitivity ( $d'$ ) in which the vertical target was discriminated from the horizontal target. Sensitivity was calculated from “hits” and “false alarms” (Stanislaw & Todorov, 1999).

### *Mindfulness*

The Norwegian version of the Five Facet Mindfulness Questionnaire (FFMQ; Dundas, Vøllestad, Binder, & Sivertsen, 2013) consists of 39 items rated on a five-point Likert scale ranging from 1 (*never true*) to 5 (*always true*). The subdimensions of the FFMQ had reasonable internal consistency: observation ( $\alpha = .78$ ), description, ( $\alpha = .84$ , after removing Item 7), acting with awareness ( $\alpha = .87$ ), nonjudgmentality ( $\alpha = .87$ ), and nonreaction ( $\alpha = .61$ , after removing Item 21 due to low reliability).

### *Mental Demand on the SART*

The SART is a demanding task where error rates are commonly high (Robertson et al., 1997). The subjective demand performing the SART was measured using a subscale of the NASA Task Load Index (NASA-TLX). The participants rated one item on a 20-point Likert scale ranging from 1 (*not demanding at all*) to 20 (*very demanding*; Hart & Staveland, 1988).

### *Anxiety*

The Norwegian Sports Anxiety Scale (SAS-n; Abrahamsen, Roberts, & Pensgaard, 2006) is a multidimensional, sport-performance, trait-anxiety inventory that is often used to investigate high-performance groups. Responses are given on a four-point scale ranging from 0 (*not at all*) to 3 (*very much*). The three subdimensions had reasonable internal consistency: somatic anxiety ( $\alpha = .81$ ), worry ( $\alpha = .88$ ), and concentration disruption ( $\alpha = .75$ ).

### Depression

We used a Norwegian version of the one-dimensional 10-item Hopkins Symptom Checklist (Strand, Dalgard, Tambs, & Rognerud, 2003). Responses are given on a four-point scale ranging from 0 (*not at all*) to 3 (*very much*) and had reasonable internal consistency ( $\alpha = .89$ ).

### Daily Positive Response Outcome Expectancies

To measure PROE, participants were asked to respond to the following question: "How well do you expect to cope with the challenges of today?" The question was answered on the mornings when saliva samples were taken and responses were given on a 10-point scale ranging from 1 (*not very well*) to 10 (*very well*).

### Sleep

On the days of saliva sampling, participants logged their number of hours of sleep and their quality of sleep on a five-point scale ranging from 1 (*very good*) to 5 (*very bad*).

### Physical Activity

Participants gave an estimate of how often they worked out per week pre- and postintervention on a scale of from 1 (*more than 2–3 passes*), 2 (*2–3 passes*), 3 (*1–2 passes*), 4 (*less than 1 pass*), and 5 (*hardly ever*).

### Demographics

Age, military experience, and whether respondents were living with a partner or not were recorded.

### Participants

The sample consisted of all available personnel at two military helicopter units ( $N = 40$ ) during their preparations for redeployment to an aeromedical mission in a conflict area. The squadrons were comparably organized, performed similar tasks, and had similar working hours, responsibilities, and characteristics (see Table 1).

TABLE 1  
Characteristics of the Mindfulness Training (MT) Group and Control Group

	MT Group ( $n = 25$ )	Control Group ( $n = 15$ )
Mean age ( <i>SD</i> )	35 years (13), range = 18–62	40 years (10), range = 26–56
Mean military experience ( <i>SD</i> )	15 years (13), range = 2–42	20 years (11), range = 7–35
Married or living with partner	16	13
Number of aircrew	16	13
Number of technicians/administrators	9	2

At the time of the experiment the personnel had been, and still were, exposed to considerable workload as a result of deployment to the conflict area combined with intensive pre- and postdeployment work. Unpublished reports from Air Force headquarters indicated that personnel in both squadrons were showing clear signs of attrition and fatigue. The mission had lasted several years when the study started, and at posttest it was still unclear how much longer the mission would last.

### Equipment

Saliva was collected using the Salivette sampling device with cotton roll. The stimuli for the cognitive tests were presented on a laptop with a 15-in. liquid crystal display (Dell™ Latitude™ E6520) located approximately 60 cm from participants. A laptop running SuperLab 4.5 software (Cedrus Corporation) controlled the timing of the events, generated stimuli, and recorded response times.

### The Intervention

The intervention followed the guidelines for the Mindfulness Stress Reduction Program (MBSR; Kabat-Zinn, 1994). It started with a 10-hr comprehensive introductory course, which was followed by weekly 3-hr sessions and twice-weekly, 20-min audio-guided personal MT sessions. To increase MT practice time, participants were encouraged to carry out everyday activities that they usually did on autopilot more mindfully (e.g., working out, talking, listening, eating, walking, driving, etc.). All MT instructors had a minimum of 10 years of meditative practice and were formally accredited MT instructors at the Scandinavian Centre for Awareness training ([www.scat.no](http://www.scat.no)). The intervention was carefully designed to fit a high-performance environment and participants' partners were also offered MT (for further details on the MT, see Meland et al., 2015).

### Procedure

Participants who were scheduled for the experiment received a short briefing about the experiment accompanied by an information letter. The MT was part of the daily planned activity at the intervention squadron and was therefore mandatory. Participants provided written informed consent to participation in the research project. The stated purpose of the experiment was "to gain a better understanding of the physiological and psychological effects of MT in high-performance cohorts." Workers who declined participation at recruitment ( $n = 3$ ) were excused from data collection procedures but otherwise followed the same program as the study participants, giving a response rate of 95%. The study was approved by the Norwegian Committee for Medical Research Ethics.

Data collection was performed at the squadrons' home base, and every effort was made to collect the data at the same time of day and week for both squadrons. To correct for seasonal differences in daylight due to the geographical locations of the squadrons, the data were collected in February and May for the MT group and in April and August for the control group.

### *Cortisol Sampling*

Participants collected saliva samples over 2 days on waking, 30 min after waking, and at bedtime. Participants were instructed to wake according to their regular schedule and collect the first sample in bed (instruction: “as soon as you open your eyes”), the second sample later (instruction: “after 30 min, but before eating, drinking, or brushing teeth”), and the last one at bedtime (instruction: “the time at which you try to go to sleep, prior to brushing your teeth”). Salivettes were refrigerated for a maximum of 2 days and returned to the investigators where they were frozen (minimum  $-18^{\circ}\text{C}$ ) until analysis. The same procedures were used at pre- and postmeasurements.

Analysis of hormones in saliva was done using liquid chromatography tandem mass spectrometry (LC-MS/MS; Jensen, Hansen, Abrahamsson, & Nørgaard, 2011). The detection limit was 0.26 nmol/l. To test equivalence between analysis, reference samples at two levels (3.22 nmol/l and 9.03 nmol/l) were analyzed with every 14 samples. Westgard control charts (Westgard, Barry, Hunt, & Groth, 1981) were used to document that the method remained under statistical and analytical control.

In accordance with current guidelines (Stalder et al., 2016), all samples taken more than 5 min outside the time window in the protocol were excluded ( $n = 4$ ), and delayed wake-up samples ( $> 20$  min postwaking) were turned into 30-min postwaking samples ( $n = 5$ ). The data were checked for outliers, but no unlikely cortisol levels were detected. Cortisol levels were averaged across the 2 days for each of the three scheduled collection times on a per-individual basis. To maximize the volume of data available for analysis, all participants with at least one valid pre- and postintervention saliva sample for a given time point were included in the analysis. Logarithmic transformations of cortisol data did not change the results of the analysis, so for ease of interpretation raw data were used in the analysis and presentation of data.

### *Cognitive Tests and Questionnaires*

All participants were briefed on the two tests on the morning prior to pretests, and received adaptation and practice, 3 min on the SART and 8 min on the ACT. Questionnaires were filled in at the end of this common session. Participants went back to their regular working positions and met at designated time slots for cognitive testing. To control for daily variations in attention, the time of day for cognitive testing was the same for pre- and posttesting. The cognitive test session started with the SART, followed by the ACT, separated by a 2-min break. A 1-min practice was included in both the SART and ACT, which was not included in the data analysis.

Prior to the SART, participants were instructed to respond to the go stimuli (1, 2, 4, and 9) with a key press and to withhold this response when the no-go stimulus (3) was presented. Prior to the ACT, participants were instructed to discriminate the orientation of the target line (vertical or horizontal) placed inside the diamond, and that the diamond appeared unpredictably but equally likely in one of six positions. Participants were instructed to respond as quickly and accurately as possible in both tests, and that the SART took 5 min to complete and the ACT took 15 min.

### Statistical Analysis

Statistics were calculated using SPSS version 22.0 (IBM Corporation, Armonk, NY). Independent-sample *t*-tests were used to assess baseline group differences. The effects of MT were assessed using mixed-factor analysis of variance (ANOVA), with one between-subject factor (MT group vs. control) and one within-subjects repeated-measures factor (pre- and postintervention). The main effects for time and group and the interaction of these factors (Time  $\times$  Group) are reported. A significant interaction effect indicates a different development (from pre to post) over time between the groups. The main effect of time reflects changes over time across groups. The main effect of group indicates that the two groups differed when collapsed across the measurement times. Paired-sample *t*-tests were performed to assess the change in mindfulness scores. The significance threshold was set at  $p < .05$  for all analyses.

## RESULTS

The analysis included 25 participants in the MT group and 15 in the control group. It should be noted that the initial size of the groups was larger. Six MT participants and 2 control group participants did not take any postintervention saliva samples due to change in workplace ( $n = 2$ ), absence due to deployment ( $n = 2$ ), sick leave ( $n = 2$ ), or forgetting ( $n = 2$ ). These were excluded from our analysis, and because there were no baseline differences between participants with and without missing postintervention saliva data, the missing data could be considered random (results not reported). It should also be noted that both high and low slope levels of cortisol and perceived concentration disruption scores were lower in the MT group compared to the control group at baseline (Table 2, Table 3 and Figure 1). No other baseline group differences were found.

### Mindfulness

Paired-sample *t*-tests revealed a pre to post increase in the observation and description facets of the FFMQ in the MT group, but not in the control group (Table 4).

### Cortisol

The mixed-factor ANOVA revealed a Group  $\times$  Time interaction on two of the cortisol measures (Table 2). The MT group displayed an increase on high and low cortisol slopes, with no change in CAR. This pre–post change is mainly due to increases in morning measures of cortisol in the MT group (Figure 1a), leaving bedtime cortisol levels unchanged. This change in morning levels of cortisol was not found in the control group (Figure 1b).

Significant Group  $\times$  Time interactions were also found in RT and self-perceived demand on the SART. On the ACT, there were main effects for time in two conditions. Referring to Table 3, there was a main effect for time on the depression scores and the worry subscale of the SAS–n, showing similar pre–post reductions in both groups on these self-perceived measures. There was also a main effect for time on the sleep measures, showing similar increases in sleep length and quality. No other interaction effects were found on any of the other measures.

TABLE 2  
Means and Standard Deviations of High and Low Cortisol Slopes, Cortisol Awakening Response, Scores on the Sustained Attention to Respond Test, and Scores on the Attentional Capture Test

	MT Group ( <i>n</i> = 25)						Control Group ( <i>n</i> = 15)						Time × Group Interaction F value, <i>p</i> value ( $\eta^2$ )
	Pre		Post		Pre		Post		Time F value, <i>p</i> value ( $\eta^2$ )	Time × Group Interaction F value, <i>p</i> value ( $\eta^2$ )			
	M	SD	M	SD	M	SD	M	SD					
<b>Cortisol</b>													
High slope (nmol/l)	6.0	3.9	8.3	4.1**	10.9	4.1	9.8	2.8**					$F(1, 38) = 5.537$ , $p = .024 (.127)^*$
Low slope (nmol/l)	2.3	1.9	4.4	2.7**	5.4	3.5	4.6	2.6**					$F(1, 38) = 6.828$ , $p = .013 (.156)^*$
CAR (nmol/l)	3.4	2.9	4.0	3.1	5.7	4.8	4.6	3.1					
Sustained attention to respond test													
Commission error	19.69	5.21	18.38	5.75	18.07	4.71	17.00	3.23					
RT (msec)	305	66	322	54	326	51	303	38					
Mental demand (rating scale = 0–20)	15.38	3.41	11.25	5.36	16.07	2.27	15.71	2.58					$F(1, 38) = 8.202$ , $p = .007 (.174)^{**}$ $F(1, 38) = 7.636$ , $p = .009 (.175)^{**}$
<b>Attentional Capture test</b>													
<i>d'</i> cued condition	1.92	1.06	2.07	1.26	2.58	1.06	2.37	.86					
<i>d'</i> Distance 1	.97	.69	1.40	.97	1.16	.41	1.21	.73					$F(1, 38) = 4.878$ , $p = .033 (.114)^*$
<i>d'</i> Distance 2	1.00	.79	1.44	.98	1.27	.44	1.45	.87					$F(1, 38) = 8.330$ , $p = .006 (.180)^{**}$
<i>d'</i> Distance 3	1.16	.94	1.59	1.02	1.34	.83	1.41	.74					
<i>d'</i> No distractor	1.44	.96	1.64	1.08	1.49	.72	1.71	.98					

Note. Differences between groups tested with a mixed between–within subjects analyses of variance (Wilks's Lambda). MT = mindfulness training; CAR = cortisol awakening response; RT = reaction time.  
\* $p < .05$ . \*\* $p < .01$ .

TABLE 3  
Means and Standard Deviations of Responses to Sport and Anxiety Scale, Sleep Length, Sleep Quality, Positive Response Outcome Expectancy, Physical Activity, and Wake-Up Time

	MT Group (n = 25)						Control Group (n = 15)						
	Pre			Post			Pre			Post			
	M	SD		M	SD		M	SD		M	SD		
Sport and Anxiety Scale: (rating scale = 0–3)													
Anxiety	.52	.24	.47	.22	.64	.25	.67	.19					
Concentration disruption	.17	.23	.10	.24*	.47	.36	.38	.75*					
Worry	.68	.34	.48	.34	.65	.35	.60	.37					$F(1, 38) = 5.984, p = .020 (.158)^*$
Depression	.26	.30	.16	.18	.36	.41	.24	.32					$F(1, 38) = 5.837, p = .022 (.154)^*$
Sleep length (hr)	6.47	.61	6.74	.61	6.71	.83	6.86	1.12					$F(1, 38) = 5.971, p = .020 (.162)^*$
Sleep quality (rating scale = 1–5)	1.95	.78	1.79	.71	2.50	1.23	2.00	1.04					$F(1, 38) = 4.910, p = .034 (.002)^*$
Positive response outcome expectancy (rating scale = 1–10)	7.50	1.46	7.60	1.31	7.71	1.07	8.00	.87					
Physical activity (rating scale = 1–5)	2.42	1.12	2.32	0.89	2.29	1.07	2.29	1.20					
Wake-up time (a.m.)	6:21	0:31	6:31	0:34	6:26	0:42	6:33	0:30					

Note. Differences between groups tested with a mixed between-within subjects analyses of variance (Wilks's Lambda). MT = mindfulness training.  
\* $p < .05$ . \*\* $p < .01$ .

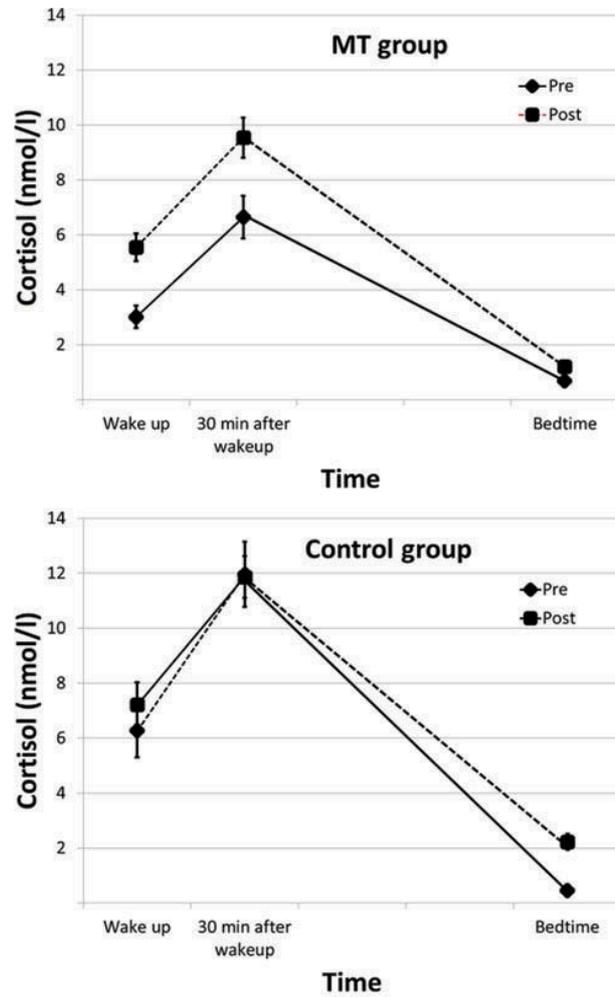


FIGURE 1 Mean salivary cortisol levels at wake-up, 30 min after wake-up, and bedtime pre- and postintervention in the (a) mindfulness training (MT) group ( $n = 25$ ), and (b) control group ( $n = 15$ ), with error bars showing standard error.

## DISCUSSION

The aim of this study was to investigate the effects of MT on stress reduction and attentional control in a high-performance cohort during a prolonged period of high-demand work. As hypothesized, we found that the intervention increased two of the five self-perceived facets of mindfulness (i.e., observation and description), confirming that the intervention efficiently affected the degree of

TABLE 4  
Pre and Post Means and Standard Deviations of the Different Facets of Mindfulness in Mindfulness Training (MT) Group and Control Group

Facet	MT Group (n = 25)				Control Group (n = 15)			
	Pre		Post		Pre		Post	
	M	SD	M	SD	M	SD	M	SD
Observation	3.00	.53	3.21*	.58	2.89	.54	2.74	.45
Description	3.16	.56	3.46**	.57	3.36	.45	3.32	.62
Act with awareness	3.48	.63	3.53	.59	3.19	.59	3.09	.63
Nonjudgmentality	3.79	.65	3.89	.65	3.85	.59	3.76	.66
Nonreactive	3.21	.60	3.36	.43	3.01	.39	2.83	.54

Note. Rating scale = 1–5.  
\*p < .05. \*\*p < .01.

mindfulness. We also found steeper cortisol slopes from morning to evening and decreased perceived mental workload on the demanding go–no go test. The findings support the proposal that the stress-reducing effects of MT are related to a more restful, alert, and flexible state of mind, allowing for adaptation and active coping responses (Moore & Malinowski, 2009; Tang et al., 2015). This also extends our previous reports that MT improves self-reported regulation of arousal and attention in already high-performing individuals (Meland et al., 2015).

### Changes Due to MT

There could be several possible explanations to the change in cortisol levels of the MT participants found in this study. Importantly, there were no indications that this change could be attributed to changes in outer workload, positive outcome beliefs, physical activity, time of wake-up, or sleep. We cannot rule out that it is partly related to a statistical artefact, regression to the mean (Bland & Altman, 1994). Still, we believe this is unlikely in this study, because we found pre–post changes in several other measures in the MT group, which were not present in the control group.

The design of the MT intervention could, of course, have played a role in the changes in cortisol, for example the plenary layout of the training sessions. Simply spending more time together in plenary sessions could have led to an increased sense of social support. The stress-reducing effects of social support are documented in demanding occupational settings (Bragard, Dupuis, & Fleet, 2015). It is also possible that spending 3 to 5 hr a week sitting or lying down in itself could have had a relaxing and restorative effect on the participants. However, the fact that we observed changes in self-perceived mindfulness in the MT group suggests that some of the beneficial effects also were due to adoption of specific mindfulness skills.

An attitude of acceptance is known to short-circuit unhelpful thought patterns and rumination (Segal, Wittmann, & Teasdale, 2002; Wells, 2011). However, a pre–post change in the nonjudgmental facet of mindfulness could not be stated. Participants could still have benefited from MT because it increases the extent to which they exposed themselves to the inner turmoil that

inevitably accompanies periods of pressure, uncertainty, and high workload. Merely to register stressful thoughts and feelings, no matter attitude, could over time result in adaptation and normalization (Hölzel et al., 2011). All other things being equal, this could have led to a reduction in the proportion of daily experience perceived as stressful to the MT participants, reducing unnecessary energy mobilization.

Another postulated consequence of MT is that one learns to notice unhelpful automatic thoughts without responding reflexively to them, including those that have previously been regarded as both positive and adaptive. For example, an inner striving to improve is considered an adaptive trait (Stoerber & Otto, 2006), but during periods of prolonged or excess pressure, an automatic tendency to “try harder” or “wishing things were different” could be the source of unnecessary energy expenditure. Successful athletes are known to have confidence and a high drive to excel (Gould & Maynard, 2009). Because the mental skills needed in sports are similar to those in the military (DeWiggins, Hite, & Alston, 2010), this could have been of particular importance to the stress-reducing effects of MT in this study. The stress response might have been further intensified because many of the stressors were beyond the control of the individuals in this study (Lazarus & Folkman, 1984). MT is in fact believed to be especially helpful in circumstances that cannot be controlled (Baer, 2003; Bishop et al., 2004). In sum, instead of striving for control or manipulating and changing thoughts, the MT participants might therefore have learned to identify unhelpful thoughts, and started to respond reflectively to them, rather than reactively. This could have lessened systemic arousal and improved their ability to recover, without a corresponding reduction in outer workload.

As stated, there are several ways MT can lessen the impact of daily stressors and increase recovery in this selected cohort, but common to all of them is that it involves a change in attentional strategy. One way of controlling attention is to force our attention back to a target when our mind wanders, striving to maintain attentional focus and judging oneself when one fails to do so. This attentional strategy has been associated with increased energy expenditure (Gross, 2002), and might over time be exhaustive. In MT one learns to allow attention to rest with alertness on the present-moment experience, gently moving it or bringing it back with no further cognitive processing. This change in attentional strategy is associated with decreased systemic arousal (Tang et al., 2015), and might account for the restorative effects of MT in this study. The lowered perceived demands imposed by the SART found in this study support this explanation and are consistent with Randomized Controlled Trials (RCTs) showing that individuals perform information-processing tasks more efficiently and with less effort after MT (Tang et al., 2015).

The slowing of RTs on the SART in the MT group supports an increased awareness in the MT group, because the opposite (i.e., speeding of RTs on the SART) has been associated with a lack of awareness and habitual responding (Cheyne, Solman, Carriere, & Smilek, 2009). We have previously found that an environmental stressor (i.e., vibration) was associated with shorter RTs on the SART in elite athletes (Ishimatsu, Meland, Hansen, Kåsin, & Wagstaff, 2016), which fits with the speeding up of RTs in the control group. Following this argument, we would have expected a significant decrease in commission errors in the MT group and an increase in the control group. This was not the case in this study.

Becoming more perceptually attuned and sensitive to inner present-moment experience has been suggested to be potentially problematic to some individuals (Segal et al., 2002; Wells,

2011). However, MT did not seem to make the current sample more vulnerable to depression, anxiety, and stimulus-driven distractions, as measured by the ACT.

### Strengths and Limitations

To our knowledge this is the first controlled study of the effects of MT in a high-performing cohort during prolonged high-demand work, using salivary cortisol and performance on tests reflecting attentional capacities important to real-life situations experienced in aviation. The sample size and duration of the intervention should have been sufficient to elicit and detect the putative effects of MT on cortisol secretion (Tang et al., 2015). Although our sample was exclusively male and might therefore be exceptional in some respects, we consider the findings to be reliable and expect they will generalize to other high-performance populations exposed to similar demands.

Although these findings lend further support to the benefits of MT for high-performance individuals, there are a number of limitations to the study. Baseline differences between the groups in the levels of cortisol, not accounted for by differences in the group characteristics, could be regarded as a limitation. This could be due to the natural between-individual difference in cortisol levels (Kudielka, Hellhammer, & Wust, 2009). However, we do not find this limitation too concerning because such differences are accounted for in the within-subjects design. The lack of an active control condition is a more serious limitation, which means we cannot separate the effects caused by MT skills and those attributable to other factors of the intervention. The fact that we also failed to find pre–post improvements in performance on the cognitive tests means that we cannot exclude the possibility that some of the stress-reducing effect of MT is attained through a reduction in overall alertness and situational awareness. Finally, we relied solely on quantitative pre- and postintervention assessments and did not carry out a follow-up assessment or collect verbal reports. This means we lack insight into individual trajectories, cultural differences, and long-term effects of MT. In sum, the findings should be replicated in other high-performance cohorts and if possible include an active controlled condition, longer test duration, follow-up measures, and qualitative interviews.

### CONCLUSION

A 4-month MT program was effective in increasing high and low cortisol slopes, leaving CAR unaffected, and reducing perceived demands on a go–no go test. The program also increased the observation and description aspects of mindfulness, indicating that the restorative effects of MT came through increased exposure to present-moment experience and a more relaxed and flexible mind, less vulnerable to habitual responding.

### Practical Implications

These findings indicate that MT could be implemented specifically to reduce stress in high-workload settings where attentiveness to the task is particularly important. This could be relevant in military and civilian aviation, as well as other high-demand contexts where external workload cannot easily be lessened.

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## PAPER IV

Meland, A., Høgmo, P. M., Ishimatsu, K., & Pensgaard, A. M. Inhibitory control is differentially associated with mindfulness facets in a high performance cohort. *Mindfulness*, (submitted, august 2016).



Mindfulness and inhibition

**Inhibitory control is differentially associated with mindfulness facets in a  
high performance cohort**

Running title: Mindfulness and inhibition

Word count: 4400 (excluding abstract)

*ABSTRACT*

Mindfulness has become a popular tool for athletes and soldiers at the highest level, but the knowledge about the exact associations between mindfulness and key performance variables on the elite level is lacking. This is problematic in environments where even minor costs of a trait or an intervention could easily outweigh the benefits. An important variable that has received no investigation in relation to mindfulness in elite cohorts is inhibitory control. Forty-two professional soccer players reported self-perceived mindfulness and performed computerized tests of response inhibition and inhibition of task irrelevant stimulus processing (i.e. attentional capture). The results showed that the observation facet of mindfulness was associated with better response inhibition, while the non-judgement factor was associated with lower levels of response inhibition due to more impulsive responding. There were also indications that the observation facet was associated with a trial-to-trial attentional flexibility on an attentional capture test. These findings suggest that trait mindfulness and inhibitory control is related, but that the relationship is not straightforward and not only beneficial.

*Key words* peak performance, elite sport, executive control, inhibition

*INTRODUCTION*

Mindful individuals are described as having contact with moment-to-moment experience, with high awareness of all stimuli, experiencing few distortions and less reactivity related to emotional valence (Bishop et al., 2004; Brown, Ryan, & Creswell, 2007). Empirical studies have shown that mindfulness can be enhanced through training and that it can have positive effects on several key functions and processes in the normal population (Grossman, Niemann, Schmidt, & Walach, 2004; Hofmann, Sawyer, Witt, & Oh, 2010). Based on the description of being mindful, this seems to be a beneficial trait also for individuals already performing at a high level. Thus, in the last decade mindfulness-training (MT) has been recommended and used as an addition to traditional psychological training in athletes as a method to increase performance-delivery in highly demanding situations (Birrer & Morgan, 2010; R othlin, Horvath, Birrer, & grosse Holtforth, 2016). There is preliminary evidence showing that being naturally mindful or engaging in mindfulness training is beneficially associated with key performance variables, such as task-orientation, flow, well-being, and anxiety in athlete cohorts (for reviews see (Birrer, R othlin, & Morgan, 2012; R othlin et al., 2016; Sappington & Longshore, 2015; Zhang, Chung, & Si, 2015). However, this research suffers from an exclusive use of subjective outcome measures, and only one study comprises athletes competing on an elite level (R othlin et al., 2016). In regards to MT, it has been successfully applied in high performance combat aviation (Meland, Fonne, Wagstaff, & Pensgaard, 2015), and MT-programs have been found to be preventive to excess stress and performance decrements in personnel exposed to highly demanding work situations (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Meland et al., 2016).

Despite promising, there is still a lack of clear evidence of the beneficial effects of being mindful on the elite level. Additionally, there are signs of a positive publication bias in the literature, leaving potential costs of being mindful largely unknown. In order to make informed decisions regarding the benefits of mindfulness in high performance cohorts, coaches and athletes need to know more about the exact association between mindfulness and key variables related to sport performance. A good place to start would be to investigate the relationship between mindfulness and higher-order control mechanisms, especially because of its potential impact on lower level regulation of attention and action.

Our executive functions (EFs) play a fundamental part in the dynamics of human cognition and action. EFs are particularly important during time constraints and in situations that require more than routine execution of automatic and overlearned schemata (Miyake et al., 2000). Recently studies using latent variable analysis have found that the inhibition-element is the most fundamental of our EFs (Miyake & Friedman, 2012). Inhibition involves using attentional control in a restraining way to prevent attentional resources being allocated to task-irrelevant stimuli and responses (Eysenck, Derakshan, Santos, & Calvo, 2007). There are several sub-categories of inhibition, in which all involve a certain degree of higher order inhibition (Verbruggen & Logan, 2008). We chose to investigate inhibition at the level of automatic task irrelevant stimulus processing (i.e. attentional capture) and response inhibition. The attentional capture phenomenon occurs when highly salient stimuli, relevant or not, is given priority by our nervous system in a bottom up manner (Theeuwes, 2014). Response inhibition refers to stopping of motor action that is no longer required or inappropriate (Verbruggen

& Logan, 2008). Insufficient inhibition in relation to attentional capture can disrupt appropriate search strategy and involves over-processing of irrelevant salient stimuli (Theeuwes, 2014), while response inhibition could reduce inappropriate and habitual responding (Helton, Kern, & Walker, 2009; Sakai, Uchiyama, Shin, Hayashi, & Sadato, 2013). Although trivial to most people, sufficient inhibitory control at the level stimulus driven attentional capture and response inhibition is highly relevant to elite groups operating in complex and rapidly changing environments. To be successful in these contexts one must be able to focus attention on the most relevant information. Make swift decisions to execute or stop an action without always having the time to absorb the whole situation, or the option to slow down to prevent mistakes. This research is important as it was recently demonstrated that higher levels of distractor interference and impulsive behaviour has been associated with more collateral damage and friendly fire incidents in a simulated combat scenario (Wilson, Head, de Joux, Finkbeiner, & Helton, 2015).

*Mechanisms and empirical evidence*

Inhibition is a fundamental ingredient in the operational definition of mindfulness (Bishop et al., 2004), and there may be at least two different mechanisms linking mindfulness to improved inhibitory functioning. Some have linked better scores on computerized tasks sensitive to inhibition to reductions in mind-wandering or higher levels of sustained attention (Cheyne, Carriere, & Smilek, 2006). An alternative explanation, upon which the current study is based, is that being mindful leads to better recruitment of higher order control mechanisms (Teper, Segal, & Inzlicht, 2013). The logic behind the latter is that the increased awareness and sensitivity found in mindful

individuals (Farb, Segal, & Anderson, 2013) transfers to increased recruitment of higher-order control mechanisms including, inhibitory control (Weinberg, Riesel, & Hajcak, 2012). As all facets of mindfulness ultimately support an undistorted awareness of present-moment experience (i.e., internal and external) (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), they may all be associated with enhanced higher-order control.

Studies on the normal population show that inhibition is the only EF that has been consistently associated with mindfulness (Gallant, 2016). On a general level there is also extensive research on the normal population suggesting that, by being mindful, you are less distracted, more sensitive to goal-relevant aspects, and can execute behaviour in a controlled manner (Tang, Holzel, & Posner, 2015). This includes interference by visual distractor stimuli (Jha, Krompinger, & Baime, 2007; Tang et al., 2007). However, we could find no study that has applied tests specifically sensitive to inhibition of task irrelevant stimulus processing at the level of attentional capture. In regards to response inhibition the findings are mixed. Some studies have found that being mindful may be associated with improved performance on go/ no-go tests (Cheyne et al., 2006; Jha et al., 2015; Jha, Morrison, Parker, & Stanley, 2016; Schmertz, Anderson, & Robins, 2009; Sahdra et al., 2011; Josefsson & Broberg, 2010). However, other studies failed to find an association between mindfulness and performance on go/ no-go tests (MacCoon, MacLean, Davidson, Saron, & Lutz, 2014), and in some studies there was even found a negative association (Larson, Steffen, & Primosch, 2013; Saunders, Rodrigo, & Inzlicht, 2015). In addition, the above-mentioned studies involved normal population cohorts, with the exception of the two controlled studies testing mindfulness training on active-duty

U.S. Army male soldiers prior to deployment to Afghanistan (Jha et al., 2015; Jha et al., 2016). In these studies it was found that eight hours MT effectively prevented decrements in performance on a go/ no-go test. Unfortunately, they did not report the level of mindfulness, which makes it difficult to pinpoint the exact relationship to the specific facets of mindfulness. Moreover, the findings are mixed and there is a lack of research on the exact associations between mindfulness and inhibitory control, particularly at the level of stimulus driven attentional capture and response inhibition.

*Aims and hypothesis*

Hypothetically, being a mindful person competing or operating at the highest level may be helpful as it involves being more attuned to momentary sensations compared to their less-mindful counterparts. However, whether this transfers to improved inhibitory control at the level of inhibition of stimulus driven attentional capture and response inhibition remain unknown. To fill this gap in the literature, the aim of the current study was to investigate the associations between trait mindfulness and objective measures of inhibition of stimulus driven attentional capture and response inhibition in an elite cohort. Due to the lack of previous research, a first step would be to investigate this in a controlled laboratory setting using standard, computer tests. We chose soccer players, because soccer is a cognitively demanding strategic game where attention- and action-control seems critical (Coutts, 2016). We chose tests measuring response inhibition and inhibition of stimulus driven attentional capture, as we argue such tests best resemble the critical moment-to-moment demands for inhibition during complex and rapidly changing real-life scenarios. Based on recent evidence from military groups (Jha et al., 2015; Jha et

al., 2016; Vestberg, Gustafson, Maurex, Ingvar, & Petrovic, 2012) and theory (Weinberg et al., 2012), we hypothesized that all facets of mindfulness would be positively associated with performance on both tests.

## *METHODS*

### *Participants and procedure*

Forty-two male players (mean age = 26.5 years, SD = 5.1) from two Norwegian professional soccer clubs were recruited through the respective head coaches. Participants took part in this study voluntarily, and provided written informed consent. The Norwegian Committee for Medical Research Ethics approved the study. Questionnaire data were collected, and two computerized tests were conducted at the players' home grounds in similar settings in both cases. The stimuli for the cognitive tests were presented on laptop computers with 15-inch liquid crystal display (Dell™ Latitude™ E6520). Participants sat in front of the display, approximately 60 cm from them. SuperLab 4.5 software (Cedrus Corporation) controlled the timing of the events, generated stimuli, and recorded reaction times. There was a two-minute break between the cognitive tests. The participants used noise-cancelling headphones (Bose QC15, Bose Corporation, Massachusetts, U.S.) throughout the test session to reduce any confounding noise effects, making the conditions similar for all participants.

### *Measures*

*Mindfulness* was assessed using the Norwegian version of the Five Facet Mindfulness Questionnaire (Dundas, Vøllestad, Binder, & Sivertsen, 2013). The

questionnaire consists of 39 items rated on a five-point Likert scale, ranging from “never true” (1) to “always true” (5). The subscales of the FFMQ had reasonable internal consistency: observation  $\alpha = .82$ , description  $\alpha = .60$  (after removing item 22, due to low reliability), act with awareness:  $\alpha = .86$ , non-judgementity:  $\alpha = .87$ , non-reaction:  $\alpha = .78$ .

*The attentional capture task (ACT)* is a visual search task (Theeuwes & Chen, 2005). The ACT is sensitive to inhibition of a task-irrelevant stimulus (i.e., distractor). Participants were instructed to discriminate the orientation of a target line (vertical or horizontal) placed inside a diamond that appears unpredictably but equally likely in one of six positions equally spaced around the fixation point on an imaginary circle. A task-irrelevant peripheral stimulus (i.e., a red blink) flashes for 60 ms at one of the six positions prior to the target appearance in 83% of the trials. The attentional capture effect is measured in five conditions, according to the presence and position of the distractor – *no distractor*: no red-blink, *cued condition*: red blink on target position, *distance 1*: red blink closest to target, *distance 2*: red blink second closest to target, *distance 3*: farthest away from target. To reduce the burden on participants, we used a shortened version of the ACT, based on one of our previous experiments (unpublished work). The task takes 15 minutes to complete. Two scores were derived from the ACT on all five conditions: mean RTs in which the vertical target was discriminated from the horizontal target and sensitivity to target ( $d'$ ). Sensitivity was calculated from “hits” and “false alarms” (Stanislaw & Todorov, 1999), allowing for the separation of perceptual and decision-level effects of attention.

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Insert Fig 1 about here

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*The sustained attention to response task (SART)* is a go/ no-go continuous performance task (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). Subjects were instructed to respond to frequent go stimuli (number 1, 2 and 4-9) with a key press and to withhold this response when the rare no-go stimulus (3) was randomly presented (11.1% of the trials). The SART is sensitive to transitory reductions in attention and the response-inhibition element of executive function (Ishimatsu, Meland, Hansen, Kåsin, & Wagstaff, 2015). The test takes 4.3 minutes to complete. Subjects were instructed to respond as quickly and accurately as possible. The primary SART measures of interest were errors of commission (responses to the rare no-go digit: 3), errors of omission (failures to respond to frequent go-stimuli), and reaction times to frequent go-stimuli (Wilson, Russell, & Helton, 2015).

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Insert Fig 2 about here

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### *Statistics*

All statistics were analysed using SPSS® version 22.0 (IBM Corporation, Armonk NY, USA). Pearson's product-moment correlation assessed associations between variables. To confirm that our shortened version of the ACT worked as intended, we used a one-way ANOVA to investigate differences in RTs between the five conditions. The significance threshold was set at  $p < .05$  for all analyses.

*RESULTS*

Analyses were based on data from 42 players on the FFMQ and SART and 40 players on the ACT, two subjects did not have time to complete the entire ACT and their data was therefore not included in the analysis. Mean FFMQ scores and correlations were calculated to establish whether there were associations between the FFMQ facets and between the FFMQ facets and performance scores on the computerized tasks (Tables 1-4).

*FFMQ*

The observation facet and non-reaction facet of mindfulness was correlated (see Table 1).

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Insert Table 1 about here

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*FFMQ & ACT*

The results of the ANOVA confirmed that the ACT worked as intended, showing the following difference in RTs: cued condition < baseline condition < distractor conditions. Mean values and Pearson product-moment correlations among the mindfulness facets, sensitivity ( $d'$ ), and RT's in each condition are shown in Table 2.

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Insert Table 2 about here

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The non-judgement facet was negatively correlated with target-sensitivity ( $d'$ ) and mean RTs in all conditions, except in distance 3 (i.e., diagonal position relative to the target) and in the baseline condition (i.e., no red blink). Furthermore, the observation and non-reaction facets were positively correlated with target-sensitivity ( $d'$ ) at the cued condition.

*FFMQ & SART*

Mean values and Pearson product-moment correlations between the mindfulness facets, errors of commission, errors of omission, and mean RT in each condition are shown in Table 3.

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Insert Table 3 about here

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The observation facet was negatively correlated with errors of commission on the SART and positively correlated with RTs. The act with awareness facet was negatively associated with omission errors, and the non-reaction facet was correlated with longer RTs. Contrary to the hypothesis, the non-judgement facet was positively correlated with errors of commission.

Mean RT was correlated with errors of commission, so to control for the influence of a speed-accuracy trade-off we calculated partial correlations (Table 4). After controlling for mean RT, errors of commission were still correlated with the observation facet, and omission errors were correlated with the act with awareness facet. The non-judgement facet was no longer correlated with any of the SART variables after controlling for mean RT, indicating the relationship between the non-judgement facet and commission errors were associated with the faster response times, and not response inhibition per se.

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Insert Table 4 about here

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### Discussion

This study was designed to investigate the hypothesized association between mindfulness and inhibitory functioning at the level of stimulus-driven attentional capture and response inhibition. We argue these sub-categories of inhibition are important to the critical moment-to-moment demands for inhibition during complex and rapidly changing

real-life scenarios. Due to the lack of previous research we chose to test this relationship in a laboratory setting in order to minimize the effects of confounding variables. We used computerized tests that were sensitive to automatic task irrelevant processing and response inhibition, yet minimize demands on other cognitive processes, such as memory, planning, and general intellectual effort.

The results show that the level of mindfulness and the general level of performance on the tests in the current study are comparable to those of recent studies conducted on elite cohorts (Meland et al., 2015; Meland et al., 2016). The results partly support previous findings, suggesting that being mindful involves improved responsiveness to events signalling the need for inhibitory control (Sanger & Dorjee, 2016), albeit this only applied to response inhibition on one of five sub-facets of mindfulness (i.e., observation). The beneficial association between the observe facet and commission errors controlled for RT can be readily explained by a heightened openness to experience. Presumably being high on the observation facet may foster an increased sensitivity and responsiveness to the short and transient affects which is associated with recruitment of higher order control mechanisms (Weinberg et al., 2012). However, whether the observation facet is related to better proactive or reactive inhibitory control processes cannot be stated from the current study. Proactive inhibitory control functions as a “brake” when future events are uncertain and enables slow but accurate responding (Aron, 2011; Sakai et al., 2013). Reactive inhibitory control involves a lessening of reaction to errors (Helton et al., 2009; Sakai et al., 2013). According to an operational definition of mindfulness (Bishop et al., 2004), being mindful may involve enhanced levels of both proactive and reactive control processes.

Not finding evidence of a link between mindfulness and the ACT in the distractor conditions was contrary to previous research on mindfulness and distractor interference (Fan, Tang, Tang, & Posner, 2015; Jha et al., 2007; Tang et al., 2007). This could be ascribed to a difference in methodology, as previous studies have used global visual-cuing tests, involving both early and late selection processes. The ACT on the other hand, is specific to early-selection processing. Early selection and automatic bottom-up processes are generally known to be harder to modulate than late-selection processes (Theeuwes, 2014). Thus, one could argue that the natural levels of mindfulness present in the soccer players may not have been sufficient to curb these bottom-up attentional capture effects. Indeed, mindfulness has only been consistently associated with changes in bottom-up processes in studies including long-term mindfulness practitioners (Chiesa, Serretti, & Jakobsen, 2013). Thus, an interesting question to pursue in future studies is whether this lack of association is specific to the current population, or those not yet exposed to mindfulness training.

Another main finding in this study was that higher levels on the non-judgement facet were associated with more commission errors and impulsive responding, indicating a loss of inhibitory control. This is contrary to previous research on MT practitioners (Teper & Inzlicht, 2014). Our findings indicate that being non-judgemental involves a lack of responsiveness to the inner affects needed to recruit higher order control mechanisms. The non-judgement facet was associated with shorter RTs in both tests. A speeding of responding has been associated with a lack of awareness, a lack of alertness and habitual responding (Cheyne, Solman, Carriere, & Smilek, 2009), supporting this interpretation. Alternatively, the non-judgemental facet could be associated with factors

such as mood, arousal, or motivation, that is also known to make participants trade accuracy for speed (Saunders et al., 2015). Nevertheless, the exact mechanism behind this association is difficult to pinpoint and should be investigated in future studies.

Although these findings were not according to hypothesis, the non-judgmental facet has previously been addressed as problematic to elite cohorts who recognize that self-evaluation and being “judgmental” can also be helpful (Birrer et al., 2012). In fact, claiming that an online monitoring of “all stimuli” is associated with improved attention and action control would be a controversial claim, as not all theory and prior research support this hypothesis. For example, studies in sport contexts have shown that paying attention to internal and external stimuli, or the step-by-step execution of motor action, can interrupt performance and increase interference from distractors (Wulf, Tällner, & Shea, 2007; Baumeister, 1984; Beilock, Carr, MacMahon, & Starkes, 2002; Masters & Maxwell, 2008). Some argue that this potential problem is counteracted by an attitude of acceptance and non-judgement learned through structured mindfulness training (Hayes, Luoma, Bond, Masuda, & Lillis, 2006). In fact, according to traditional mindfulness teachings true openness to experience (i.e. non-judgementality) is cultivated through present-centred awareness, and not by actively engaging in an attitude of nonjudgement, which may instead bias reality (Rapgay & Bystrisky, 2009). Notwithstanding, an interesting question to pursue in the future is whether the negative association between non-judgement facet and inhibition specifically applies to the soccer players in the current study, or if it replicates to other elite cohorts. Further, if it could be counteracted through MT.

An unexpected, but beneficial finding in the current study was the positive correlation between mindfulness and target-sensitivity in the cued condition of the ACT. This was related to the observation and non-reaction facets, meaning that athletes high on these facets could utilize the red blink, helping them to respond quicker and more accurate in the cued trials, without being more vulnerable to interference from the same stimuli on the distractor trials. This confirms previous research linking mindfulness with executive flexibility (Hodgins & Adair, 2010), and extends this to also apply to early-selection processing in elite athletes. MT has previously been found to reduce perceptual threshold (Jensen, Vangkilde, Frokjaer, & Hasselbalch, 2012), meaning that an enhanced trial-to-trial flexibility between cued-, uncued- and distractor-trials may be directly related to the quality of inputs, leaving those high in the observation and non-reaction facets with more time to select their response.

One could speculate that being higher on the observation and non-reaction facets of mindfulness would be related to the more skilled-soccer players. This could not be stated in the current study, as we have no data on actual soccer performance. However, it is well established that a key to expert performance is to use the resources of the brain in a strategic and flexible manner (Eisenberger, Lieberman, & Satpute, 2005). Specifically related to gaze behaviour, studies on soccer players using eye-movement technology shows that, compared to their less-skilled counterparts, skilled soccer players have fewer fixations of longer duration on selected areas containing more sophisticated stimuli (i.e. the position of the sweeper and free space, rather than salient stimuli, such as the ball or an attacker) (Williams, 2000). This finding is clearly an important one, as a trial-to-trial flexibility would be beneficial to individuals operating in complex and rapidly changing

environments, where teammates, opponents, and cues continually change between being relevant and irrelevant to the task at hand.

Interestingly, we found no correlations between the five mindfulness facets, except between the observation and non-reaction facets. Although previous research has found that mindfulness consists of distinct facets, they are also linked (Baer et al., 2006; Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008). Concerning the link between the observation and non-reaction facets, most neurological research indicates that a direct and open exposure to aversive stimuli and inner turmoil (i.e. observation) leads to extinguished activation responses (i.e., non-reactivity) (Hölzel et al., 2011; Baer, 2003). There are studies suggesting this link might be particularly strong in elite groups who are routinely exposed to interoceptive perturbations (Haase et al., 2015). However, this should be further investigated in the future, especially because studies using neurological measures has found a distinction between these two facets in the normal population (Anicha, Ode, Moeller, & Robinson, 2012).

We found a number of associations between mindfulness and the measures of inhibitory control in the current study, but there were also a striking number of non-significant correlations. The description facet did not correlate with performance on any of the tests. It could be that an ability to describe your feelings (i.e., in a language manner) reflects awareness of more long-lived emotional states and not the transient affective bursts needed to initiate executive-control. Whether this is specific to MT-naïve populations should again be pursued, as the only previous study we found with a positive correlation between the description facet and response inhibition included MT practitioners and non-practitioners (Josefsson & Broberg, 2010). The act with awareness-

facet was positively associated with errors of omission on the SART, suggesting that this facet is related to sustained attention rather than inhibitory control, per se (Cheyne et al., 2009). The act with awareness facet measures rather molar tendencies toward acting on autopilot (e.g., “I snack without being aware that I am eating”). Such general tendencies may help sustain attention to a task, but similar to the description facet it could not predict the sensitivity needed to be responsive to the transient affective bursts signalling the recruitment of executive control mechanisms. Another possibility is that the ACT and SART lack the sensitivity to pick up some of the variance in inhibitory control. For example, ERP studies have shown consistent changes in brain states associated with conflict monitoring without finding changes in the behavioural measures (Fan et al., 2015). Furthermore, the ACT and SART are tests specifically designed to tap impulsivity and stimulus-driven attentional capture, which relates to early processes in the perceptual-action sequence (Robertson et al., 1997; Theeuwes, 2014). However, mindfulness has been associated with benefits in both early- and late perceptual processing (Chiesa, Calati, & Serretti, 2011; Jensen et al., 2012; Moore & Malinowski, 2009), meaning that any variance in inhibitory control affecting late perceptual processing was not captured in the current study.

#### *Strengths and limitations*

Our approach is novel, as this is the first time behavioural signatures of mindfulness have been investigated in the context of an elite cohort. Inhibition is regarded the hallmark of higher-order control functioning, and the tests reflect sub-categories of inhibition important to elite individuals operating in environments

characterized by complexity and rapid change. The use of standardized tests makes the study easy to replicate, and the results should be reliable and comparable across high-performance populations. Despite its strengths, this study also has limitations. The cross-sectional design means that one can say nothing about causality. The tasks used in the current study are designed to pinpoint the exact associations between mindfulness and inhibition at the level of stimulus driven attentional capture and motor inhibition and does not reflect the combined use of a wide range of skills needed during real-life scenarios. This research was also based on hand-to-eye coordination and fine-motor coordination, while many environments also requires eye-to-foot and gross-motor coordination. As we applied specific tests of sub-categories of inhibition there may be considerable variation in more global inhibitory control, which is unaccounted for in the current study.

#### Summary and conclusions

The current study marks a first step in the investigation of the associations between mindfulness and inhibitory control in elite cohorts. Higher levels on the observation facet of mindfulness were associated with higher levels of response inhibition and, together with the non-reaction facet, were associated with a trial-to-trial attentional flexibility. The non-judgement facet, on the other hand, was associated with more impulsive responding and a loss of inhibitory control in relation to stimulus-driven attentional capture. Moreover, our findings suggests that when it comes to momentary tasks involving inhibitory-control, being a mindful elite individual may be associated with benefits and costs, depending on what facets are more pronounced in the individual. These findings may inform stakeholders on the potential costs and benefits of being

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mindful at the elite level. It may be of particular applied interest because inhibition is the most fundamental of our EFs and also an important ingredient in the operational definition of mindfulness (Bishop et al., 2004). The next step would be to investigate whether these findings can be replicated in other elite cohorts, including those who have already engaged in MT.

*Compliance with Ethical Standards* The research was conducted in accordance with APA ethical guidelines. All participants provided informed consent, and confidentiality and anonymity were assured.

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Table 1

Mean scores and correlation coefficients ( $r$ ) between the five facets of mindfulness.

	Mean Score	SD	Description	Act with awareness	Non- judgement	Non-reaction
Observation	3.08	0.68	.203	.147	-.266	.317*
Description	3.52	0.63		.146	.120	.126
Acting with awareness	3.60	0.67			.209	-.085
Non-judgement	3.59	0.71				-.247
Non-reactive	3.12	0.59				-

Scale (1-5):

Table 2

Mean scores and correlation coefficients ( $r$ ) between FFMQ and ACT variables

	Mean Score	SD	Observat ion	Descrip tion	Act with awareness	Non- judgem ent	Non-reaction
$d'$ cued	2.53	1.00	<b>.405*</b>	.064	.125	<b>-.395*</b>	<b>.430**</b>
$d'$ distance 1	1.83	1.00	.119	-.010	.162	<b>-.355*</b>	.260
$d'$ distance 2	2.11	1.19	.160	-.020	.139	<b>-.434**</b>	.136
$d'$ distance 3	1.93	0.89	.276	.041	.118	<b>-.398*</b>	.264
$d'$ baseline	2.23	0.94	.214	-.147	.250	-.279	.193
RT cued	710.59	117.55	.201	.067	.034	<b>-.359*</b>	-.151
RT distance 1	784.84	141.67	.290	.068	.067	<b>-.392*</b>	.075
RT distance 2	782.40	153.87	.269	.080	.045	<b>-.372*</b>	.055
RT distance 3	788.12	153.36	.239	.030	.036	-.287	.086
RT baseline	748.47	141.72	.222	.013	.042	<b>-.401*</b>	.002

Table 3

Mean scores and correlation coefficients ( $r$ ) between FFMQ and SART variables

	Mean Score	SD	Errors of omission $n$	RT	RTCV	Observat ion	Descrip tion	Act with awareness	Non- judgem ent	Non-reaction
Errors of commission	18.67	5.00	.282	<b>-.801<sup>**</sup></b>	.164	<b>-.454<sup>**</sup></b>	-.265	-.280	<b>.346<sup>*</sup></b>	-.243
Errors of omission	8.81	10.32	-	-.121	<b>.538<sup>**</sup></b>	.124	-.141	<b>-.358<sup>*</sup></b>	.009	.033
RT	302.26	44.00	-	-	.082	<b>.324<sup>*</sup></b>	.281	.298	<b>-.326<sup>*</sup></b>	<b>.362<sup>*</sup></b>
RTCV	0.22	0.10	-	-	-.184	-.175	-.067	.077	-.251	-

SART variables:

Table 4

*Partial correlation coefficients between FFMQ and SART variables.*

	<i>Errors of omission</i>	<i>RTC</i>	<i>Observation</i>	<i>Description</i>	<i>Act with awareness</i>	<i>Non-judgement</i>	<i>Non-reaction</i>
Errors of commission	.198	.240	<b>-.346*</b>	-.063	-.065	.146	.100
Errors of omission	-	<b>.392*</b>	.204	-.090	<b>-.319*</b>	-.061	.117

*SART variables:*

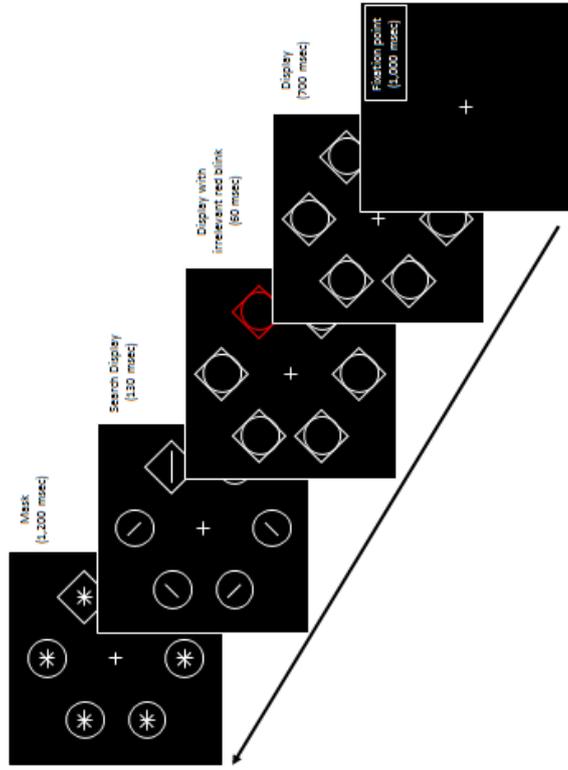


Figure 2. A graphical illustration of the sequence and timing of stimulus events presented on each trial in the Attentional Capture Test (ACT).

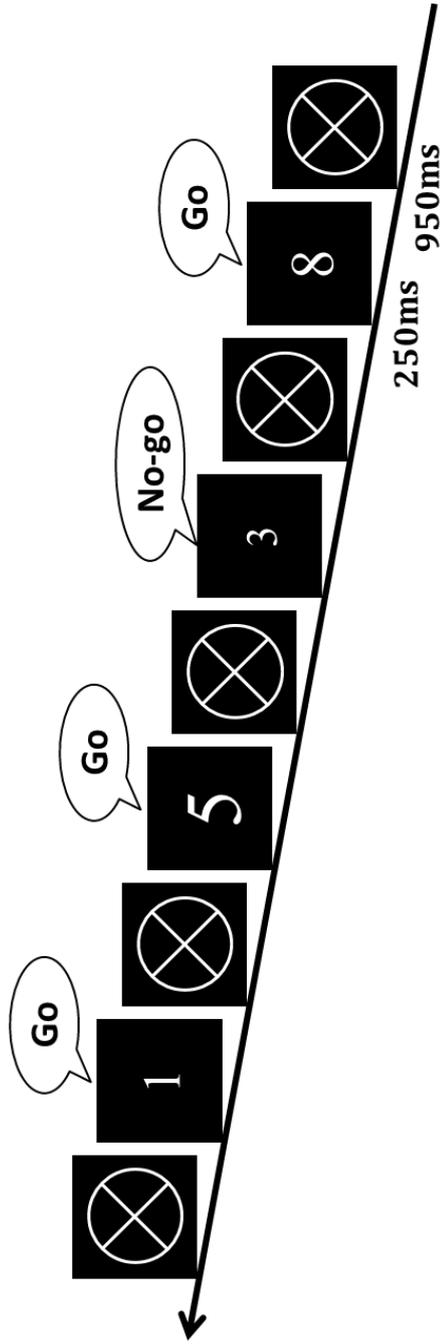


Fig 2. A graphical illustration of the sequence and timing of stimulus events presented on each trial in the Sustained Attention to Response Test (SART).

## APPENDIX I

Study information and consent forms for all studies.





## Forespørsel om deltakelse i forskningsprosjekt

### *”Mental trening 331. jagerflyskvadron.*

#### **Bakgrunn og hensikt**

Dette er et spørsmål til deg om å delta i et forskningsprosjekt for å undersøke effekten av en spesiell type systematisk mental trening. Etter ønske fra prosjektgruppen forespørres du og de andre på skvadronen om å delta i prosjektet. Prosjektet er et samarbeid mellom Forsvarets sanitet/Flymedisinsk institutt (FMI) og Norges idrettshøgskole (NIH). FMI leder selve gjennomføringen av prosjektet og NIH står som faglig ansvarlig.

#### **Hva innebærer studien?**

Prosjektet strekker seg over 12 mnd og med dagsseminar hver 3dje uke med foredrag praksis og en 10-20 min individuell samtale for spørsmål, erfaringer, utfordringer ved praktiseringen. Denne delen av prosjektet ledes av instruktør fra FMI. I tillegg innebærer prosjektet daglig egentrening mellom dagsseminarene samt utfylling av spørreskjema før, under og etter prosjektet + et 30 min intervju etter prosjektet.

#### **Mulige fordeler og ulemper**

Denne type mental trening regnes som et verktøy for personlig stressreduksjon, økt trivsel og økt oppmerksomhet på jobb, hjemme og i livet forøvrig. Samtidig kan det være at egentreningen kan oppleves som utfordrende og at det kan være vanskelig å sette av tid til den anbefalte egentreningen. Vi gjør samtidig oppmerksom på tidsbruken det medfører å fylle ut de 3 spørreundersøkelsene og et 30 min intervju.

#### **Hva skjer med informasjonen om deg?**

Informasjonen som registreres om deg er kun grunnleggende personalia, utfylte spørreskjema og intervjudata. Disse skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn eller andre direkte gjenkjenkende opplysninger. En kode knytter deg til dine opplysninger og besvarelser gjennom en navneliste. Dvs. at opplysningene er avidentifisert, og publiseres uten at identiteten til deltakeren vil kunne komme frem. Dataene oppbevares i henhold til reglene for oppbevaring av personopplysninger. Det er kun autorisert personell knyttet til prosjektet som har adgang til dataene. Navneliste og utfylte spørreskjema vil bli makulert etter prosjektets slutt (senest etter 5 år).

#### **Frivillig deltakelse**

Alle på skvadronen kan delta i studien, bortsett fra om du har hatt omfattende tidligere erfaring med meditasjon eller mindfulness trening tidligere. For at vi skal kunne fremskape viktig kunnskap om dette temaet håper vi du er villig til å delta, men minner om at det er frivillig å delta i studien. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på baksiden av dette skrivet. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling. Dersom du senere ønsker å trekke deg eller har spørsmål til studien, kan du kontakte prosjektgruppen på telefon/SMS:

Vivianne Fonne: 48010686 eller Anders Meland: 95227021.



### **Rett til innsyn og sletting av opplysninger.**

Hvis du sier ja til å delta i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra studien, kan du kreve å få slettet innsamlede opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Prosjektet er finansiert gjennom forskningsmidler fra Forsvarets innovasjon, nettverkskapasiteter og informasjons-infrastrukturstab, avdeling for konseptutvikling og eksperimentering (INI/CD & E).

### **Informasjon om utfallet av studien**

Deltakere i studien har rett til å få informasjon om utfallet/resultatet av studien. Det blir gjennomført en brief av resultatene for skvadronen før endelig rapport og publisering.

## **Samtykke til deltakelse i studien**

**Sted/Dato:** \_\_\_\_\_

Jeg er villig til å delta i studien

-----  
(Signert av prosjektdeltaker, dato)

Jeg bekrefter å ha gitt informasjon om studien

-----  
(Signert, rolle i studien, dato)

## Forespørsel om deltakelse i forskningsprosjektet

### ”VISUELL OPPMERKSOMHET, VIBRASJON OG HYPOKSI”

#### **Bakgrunn og hensikt**

Dette er et spørsmål til deg om å delta i en forskningsstudie for å se hvilken effekt lavt oksygentrykk og vibrasjon har på din visuelle oppmerksomhet.

Forskningsstudien gjennomføres ved Flymedisinsk Institutt (FMI) på Blindern. FMI er en avdeling av Forsvarets Sanitet, og har som oppgave å drive helsekontroll og medisinsk testing av flygende personell i forsvaret. I tillegg drives det forskning på medisinske problemstillinger relatert til flygning.

Flyoperativt personell utsettes for vibrasjon og endringer i oksygentrykk under flygning. Vibrasjon kan medføre forstyrrelser og påvirke evnen til å være oppmerksom. Hypoksi (lavt oksygeninnhold i kroppen) fører også til manglende årvåkenhet.

Flyoperativt personell utsettes for vibrasjon under flygning. Når det gjelder hypoksi vil blodet bli fullmettet med oksygen i høyder opp til 3000m. Flyoperativt personell kan likevel bli utsatt for høyder over dette, og hypoksi er derfor en relevant problemstilling. Å opprettholde en oppmerksom årvåkenhet under press er også en relevant problemstilling for andre prestasjonsgrupper, f.eks idrett.

Med denne studien, ønsker vi å undersøke om, og i hvilken grad, vibrasjon og hypoksi påvirker visuell oppmerksomhet. Hver for seg og sammen.

#### **Hva innebærer studien?**

Studien går over to dager.

Første dag: Går med til en generell helsekontroll for å forsikre oss om at du er frisk. En lege vil undersøke deg; tar opp sykehistorie, måler blodtrykk, hemoglobin-nivå, lytter på hjerte og lunger. Det blir også tatt en lungefunksjonstest og en test i trykkammeret hvor det simuleres en høyde på 2500 m. Dette gjøres før å teste om du er i stand til å trykkutligne. Lufttrykket på 2500 m høyde tilsvarer lufttrykket i kabinen i et passasjerfly.

Andre dag:

Når du ankommer Flymedisinsk institutt på testdagen henvender du deg i resepsjonen der du blir tatt hånd om av en prosjektmedarbeider. Du får en gjennomgang av forsøket og tid til å øve deg på de PC testene du skal utføre under selve forsøket.

Selve forsøket:

I et trykkammer simuleres 3 høyder, fra bakkenivå (0 m) til maks 4879 m. Du tilbringer ca 30 min på hver høyde. De første ca. 8 min på hver høyde sitter du i ro uten å foreta deg noe spesielt. Du vil utføre tester av visuell oppmerksomhet 2 ganger på hver høyde (til sammen 6 ganger). Halve tiden på hver høyde blir du utsatt for vibrasjon. Etter 30 min på en høyde ”forflyttes” du til neste høyde. Du vil ikke få vite på hvilken høyde du til en hver tid befinner deg, derfor vil rekkefølgen på hvilken høyde du går til først og sist avgjøres ved loddtrekning. Du vil ikke få tilført ekstra oksygen under forsøket. Hele forsøket tar ca. 3 timer fra du kommer til du er ferdig.

Under forsøket i trykkammeret, registreres det, rutinemessig, hjertemålinger, puls, mengde karbondioksid du puster ut og oksygenmetning (via probe på fingeren). Hele forsøket filmes.

### **Mulige fordeler og ulemper**

Når du bli utsatt for lavt lufttrykk, vil du kanskje oppleve at du blir andpusten og får høyere puls. Dette er normale reaksjoner. Selv om det er lite sannsynlig, kan det skje at du opplever å bli kvalm og får hodepine. Hvis det skjer, blir forsøket avbrutt. Du blir nøye fulgt opp av kvalifisert personell underveis i hele forsøket.

På grunn av vibrasjon, hypoksi og oppmerksomhetstestene som krever konsentrasjon vil du kanskje oppleve at forsøket er noe anstrengende. Du bør derfor legge opp til å ta det med ro resten av dagen etter at forsøket er avsluttet.

### **Hva skjer med prøvene og informasjonen om deg?**

Prøvene tatt av deg og informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene og prøvene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger og prøver gjennom en navneliste.

Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til deg. De rutinemessige dataene fra kammerkjøringen (blodtrykk, puls, oksygen metning og filmklipp) lagres i FMI's journalsystem, med navn og personnummer.

Informasjon gitt under legeundersøkelsen er kun tilgjengelig for undersøkende leger.

Det vil ikke være mulig å identifisere deg i resultatene av studien når disse publiseres.

### **Frivillig deltakelse**

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dette vil ikke få konsekvenser for din videre behandling. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling. Dersom du senere ønsker å trekke deg eller har spørsmål til studien, kan du kontakte følgende personer i prosjektgruppen

<b>Anders Meland, Ansvarlig for gjennomføring</b>	<b>mob: 952 27 021</b>
<b>Tor Are Hansen, Prosjektleder</b>	<b>mob: 992 78 385</b>
<b>Anthony Wagstaff, Direktør Flymedisinsk institutt</b>	<b>mob: 480 10 690.</b>

**Ytterligere informasjon om studien finnes i kapittel A – utdypende forklaring av hva studien innebærer.**

**Ytterligere informasjon om biobank, personvern og forsikring finnes i kapittel B – Personvern, biobank, økonomi og forsikring.**

**Samtykkeerklæring følger etter kapittel B.**

## **Kapittel A- utdypende forklaring av hva studien innebærer**

### **Eksklusjonskriterier**

Du kan **ikke** delta i studien hvis du oppfyller ett eller flere av kriteriene under:

- Røyker

Har eller har hatt:

- Opphold i høyden (> 2000 m) de siste to ukene før forsøket starter.
- Alvorlig hodeskade, langvarig bevisstløshet, hyppige besvimelser, krampeanfallet, epilepsi.
- Hjerte/kar sykdom.
- Lungesykdom som astma, kronisk bronkitt, gjennomgått pneumothorax eller gjennomgått operasjoner der brystkassen er åpnet.
- Symtomer på trykfallsyke ved flyging/dykking.
- Trykkutlikningsproblemer fra bihuler, tenner, mage/tarm eller hyppige øreproblemer ved flyging/dykking. (Deltakerne vil gjennomføre en kammerkjøring opp til 2500 m for å kartlegge eventuelle problemer med trykkutligning.)

Har ved forsøkets start:

- Forkjølelse, høysnue, allergi, bihulebetennelse eller andre plager som gir tetthet i øre/nese/bihuler.
- Kvalme, oppkast, diaré eller magesmerter, feber, muskelsmerter eller hang over.
- Nylige skader i muskel/skjelettsystemet.
- De siste dagene gitt blod, fått vaksiner, vært hos tannlege eller drevet med dykking/dykkerkammer.
- Er under behandling hos lege eller står på medisiner.
- Holdepunkter for at forsøkspersonen kan være gravid.

### **Forholdsregler i forbindelse med forsøket**

Du må avstå fra alkohol 24 timer før forsøket starter. Du bør også være uthvilt.

## **Kapittel B - Personvern, biobank, økonomi og forsikring**

### **Personvern**

Opplysninger som registreres om deg er:

- Høyde, vekt

Flymedisinsk Institutt ved administrerende direktør er databehandlingsansvarlig.

### **Rett til innsyn og sletting av opplysninger om deg og sletting av prøver**

Hvis du sier ja til å delta i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra studien, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

### **Økonomi og forswarets rolle**

Studien er finansiert gjennom interne driftsmidler fra forsvaret.

### **Forsikring**

Deltakerne i studien er forsikret gjennom egen forsikringsavtale.

### **Informasjon om utfallet av studien**

Hvis du ønsker det, vil du få informasjon om resultatene fra studien.

## **Samtykke til deltakelse i studien**

Jeg er villig til å delta i studien

-----  
(Signert av prosjektdeltaker, dato)

Stedfortredende samtykke når berettiget, enten i tillegg til personen selv eller istedenfor

-----  
(Signert av nærstående, dato)

Jeg bekrefter å ha gitt informasjon om studien

-----  
(Signert, rolle i studien, dato)



## Forespørsel om deltakelse i prosjekt:

### *”Mental trening og høyprestasjon”*

#### Bakgrunn og hensikt

Du forespørres med dette om å delta i et prosjekt der vi undersøker eventuell objektiv effekt av en spesiell form for mental trening, mindfulness. Dette er en type mental trening som synes å ha god effekt på prestasjon hos eliteutøvere innen idrett og som også har vist lovende effekter på personell tilhørende 331. jagerflyskvadron. Prosjektet er et samarbeid mellom Forsvarets Sanitet v/Flymedisinsk institutt (FMI), Luftforsvaret v/Flytryggingssinspektoratet, Norges idrettshøgskole (NIH) og Olympiatoppen. FMI leder selve gjennomføringen av prosjektet og er sammen med NIH faglig ansvarlig.

#### Hva innebærer den mentale treningen?

Prosjektperioden vil strekke seg over ca. 12 mnd, og selve den mentale treningen vil foregå over en periode på 3 mnd. Intervensjonen består av daglig egentrening, dagsseminar m/foredrag og øvelser i mental trening samt mulighet for 10-20 min individuelle samtaler for spørsmål/erfaringer knyttet til treningen. All undervisning og samtaler gjennomføres av instruktører med utdannelse og erfaring innen mindfulness trening. I egentreningen benyttes lydspor og arbeidshefter. Denne type mental trening har ingen kjente bivirkninger, og regnes som et verktøy for personlig utvikling, stressreduksjon, trivsel og økt oppmerksomhet.

#### Hva skjer med informasjonen om deg?

All innhentet informasjon vil behandles konfidensielt, og alle prosjektmedarbeidere har taushetsplikt. Resultatene vil bli presentert på en slik måte at det er umulig å identifisere deg. Spørreskjema vil ikke inneholde navn på den enkelte deltager, men kodes med et ID nummer. Koden mellom navn og ID nummer oppbevares i låste arkiver ved Flymedisinsk institutt. Dataene oppbevares i henhold til reglene for oppbevaring av personopplysninger. Det er kun autorisert personell knyttet til prosjektet som har adgang til dataene. Navneliste og utfylte spørreskjema vil makuleres etter prosjektets slutt (ca 2016), kun avidentifiserte data vil lagres videre.

#### Evaluering

Å gjøre en grundig evaluering av prosjektet er viktig som beslutningsgrunnlag for videre anbefaling av denne type trening i Luftforsvaret, Forsvaret for øvrig og andre prestasjonsmiljøer. Dette innebærer at det vil bli gjennomført målinger ved oppstart av prosjektet, halvveis og rett etter prosjektet er ferdig og 6-12 mnd. etter prosjektet er avsluttet. Til dette benyttes spørreskjema, fysiologiske prøver, PC baserte tester og et avsluttende intervju (se bakside for nærmere beskrivelse av målemetoder).

#### Rapport

På bakgrunn av resultatene vil det utarbeides en intern rapport samt vitenskapelige artikler som presenteres i offentlige publikasjoner.



## Målemetoder:

### Subjektive mål:

Spørreundersøkelsen er estimert å ta ca. 40-60 min å fylle ut. Den inneholder spørsmål omkring dine mentale prosesser, stress og jobbsituasjon. I tillegg gjennomføres det et 30 min intervju etter intervensjonen er gjennomført. Hensikten med intervjuet er å få mer detaljert informasjon fra deg omkring din motivasjon underveis, hvordan du opplevde treningen og eventuelle opplevde effekter av treningen.

### Fysiologiske prøver:

For å avdekke eventuelle endringer i stressreaksjon benyttes måling av kortisol, melatonin og testosteron i spytt som objektive indikatorer. Ved hver av de tre testgjennomføringene vil du bli bedt om å avgi 6 spyttprøver ilt. 2 dager. Prøvene gjennomføres på egenhånd og leveres på nærmere avtalt sted for sending og lagring i Uni Helse Bergen sin godkjente forskningsbiobank. Vi ber om at du gir din tillatelse til at spyttprøvene kan sendes videre til Arbeidsmiljøinstituttet i København for å bli analysert der. Prøvene vil destrueres etter analyse. Etter at forskningsprosjektet er avsluttet vil analyseresultatene av spyttprøvene bli anonymisert og kun inngå i laboratoriets forskningsdatabank.

### Kognitive tester

For å avdekke eventuelle endringer i visuell oppmerksomhet gjennomføres det ved hver testgjennomføring to korte PC baserte oppmerksomhetstester (på til sammen 20 min).

## Frivillig deltakelse:

Selve den mentale treningen som er satt opp i dette prosjektet er en prioritert aktivitet på skvadronen og en del av arbeidsplanen din. Når det gjelder evalueringsdelen av prosjektet er dette frivillig. Du kan når som helst trekke deg fra denne delen av prosjektet uten å gi nærmere forklaring. Dersom du trekker deg fra studien, kan du kreve å få slettet innsamlede opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Samtidig oppfordrer vi deg på det sterkeste til å delta på evalueringen da dette er helt avgjørende for å kunne evaluere effekten av denne type trening for deg, skvadronen og forsvaret forøvrig.

## Etikk

Du vil bli informert om eventuelle funn i spyttprøvene som krever særlig oppfølging. Prosjektet er tilrådd av Regional komité for medisinsk forskningsetikk i Helseregion sør/øst.

### Eventuelle spørsmål kan rettes til:

Anders Meland  
Flymedisinsk institutt - Blindern  
Mob: 95227021.

Seniorrådgiver Vivianne Fonne:  
Flymedisinsk institutt – Blindern  
Mob: 48010686



## Samtykke til deltakelse i studien

Jeg har mottatt skriftlig og/eller muntlig informasjon om prosjektet og samtykker i at jeg deltar i utprøvingen og målingen av effekt av mental trening for høyprestasjonsgrupper. Jeg gir med dette også mitt samtykke til at spyttprøvene mine kan sendes ut av landet for å bli analysert.

Jeg er kjent med at min deltagelse i selve evalueringsdelen av dette prosjektet er frivillig og at jeg når som helst kan trekke meg fra denne delen av prosjektet uten nærmere forklaring.

**Sted/Dato:** \_\_\_\_\_

**Navn m/blokkbokstaver:** \_\_\_\_\_

**Deltakers underskrift:** \_\_\_\_\_

**Jeg bekrefter å ha gitt informasjon om studien**

**Anders Meland**

-----  
(Leder for gjennomføringen av prosjektet, Dato:      )



NORGES IDRETTSHØGSKOLEN





NORGES IDRETTSHØGSKOLE



## Forespørsel om deltakelse i prosjekt:

### *”Mental trening og høyprestasjon”*

#### Bakgrunn og hensikt

Du forespørres med dette om å delta i et prosjekt der vi undersøker eventuell objektiv effekt av en spesiell form for mental trening, mindfulness. Dette er en type mental trening som synes å ha god effekt på prestasjon hos eliteutøvere innen idrett og som også har vist lovende effekter på personell tilhørende 331. jagerflyskvadron. Prosjektet er et samarbeid mellom Forsvarets Sanitet v/Flymedisinsk institutt (FMI), Luftforsvaret v/Flytryggingssinspektoratet, Norges idrettshøgskole (NIH) og Olympiatoppen. FMI leder selve gjennomføringen av prosjektet og er sammen med NIH faglig ansvarlig.

#### Hva innebærer den mentale treningen?

Prosjektperioden vil strekke seg over ca. 12 mnd, og selve den mentale treningen vil foregå over en periode på 3 mnd. Intervensjonen består av daglig egentrening, dagsseminar m/foredrag og øvelser i mental trening samt mulighet for 10-20 min individuell samtale for spørsmål/erfaringer knyttet til treningen. All undervisning og samtaler gjennomføres av instruktører med utdanning og erfaring innen mindfulness trening. I egentreningen benyttes lydspor og arbeidshefter. Denne type mental trening har ingen kjente bivirkninger, og regnes som et verktøy for personlig utvikling, stressreduksjon, trivsel og økt oppmerksomhet.

#### Hva skjer med informasjonen om deg?

All innhentet informasjon vil behandles konfidensielt, og alle prosjektmedarbeidere har taushetsplikt. Resultatene vil bli presentert på en slik måte at det er umulig å identifisere deg. Spørreskjema vil ikke inneholde navn på den enkelte deltager, men kodes med et ID nummer. Koden mellom navn og ID nummer oppbevares i låste arkiver ved Flymedisinsk institutt. Dataene oppbevares i henhold til reglene for oppbevaring av personopplysninger. Det er kun autorisert personell knyttet til prosjektet som har adgang til dataene. Navneliste og utfylte spørreskjema vil makuleres etter prosjektets slutt (ca 2016), kun avidentifiserte data vil lagres videre.

#### Evaluering

Å gjøre en grundig evaluering av prosjektet er viktig som beslutningsgrunnlag for videre anbefaling av denne type trening innen toppidrett og andre prestasjonsmiljøer. Dette innebærer at det vil bli gjennomført målinger ved oppstart av prosjektet, halveis og rett etter prosjektet er ferdig og 6-12 mnd etter prosjektet er avsluttet. Til dette benyttes spørreskjema, fysiologiske prøver, PC baserte tester og et avsluttende intervju (se bakside for nærmere beskrivelse av målemetoder).

#### Rapport

På bakgrunn av resultatene vil det utarbeides en intern rapport samt vitenskapelige artikler som presenteres i offentlige publikasjoner.



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## Målemetoder:

### Subjektive mål:

Spørreundersøkelsen er estimert å ta ca. 40-60 min å fylle ut. Den inneholder spørsmål omkring dine mentale prosesser, stress og jobbsituasjon. I tillegg gjennomføres det et 30 min intervju etter intervensjonen er gjennomført. Hensikten med intervjuet er å få mer detaljert informasjon fra deg omkring din motivasjon underveis, hvordan du opplevde treningen og eventuelle opplevde effekter av treningen.

### Fysiologiske prøver:

For avdekke eventuelle endringer i stressreaksjon benyttes måling av kortisol, melatonin og testosteron i spytt som objektive indikatorer. Ved hver av de tre testgjennomføringene vil du bli bedt om å avgi 6 spyttprøver. Prøvene gjennomføres på egenhånd og leveres på nærmere avtalt sted for sending og lagring i Uni Helse Bergen sin godkjente forskningsbiobank. Vi ber om at du gir din tillatelse til at spyttprøvene kan sendes videre til Arbeidsmiljøinstituttet i København for å bli analysert der. Prøvene vil destrueres etter analyse. Etter at forskningsprosjektet er avsluttet vil analyseresultatene av spyttprøvene bli anonymisert og kun inngå i laboratoriets forskningsdatabank.

### Kognitive tester

For å avdekke eventuelle endringer i visuell oppmerksomhet gjennomføres det ved hver testgjennomføring to korte PC baserte oppmerksomhetstester (på til sammen 20 min).

## Frivillig deltakelse:

Selve den mentale treningen som er satt opp i dette prosjektet er en del av den daglige treningen i klubben og derfor å regne som obligatorisk. Når det gjelder evalueringdelen av prosjektet er dette frivillig. Du kan når som helst trekke deg fra denne delen av prosjektet uten å gi nærmere forklaring. Dersom du trekker deg fra studien, kan du kreve å få slettet innsamlede opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Samtidig oppfordrer vi deg på det sterkeste til å delta på evalueringen da dette er helt avgjørende for å kunne evaluere effekten av denne type trening for deg, laget, toppidretten og øvrige prestasjonsmiljøer.

## Etikk

Du vil bli informert om det eventuelle funn i spyttprøvene som krever særlig oppfølging. Prosjektet er tilrådd av Regional komitè for medisinsk forskningsetikk i Helseregion sør/øst.

### Eventuelle spørsmål kan rettes til:

Anders Meland  
Flymedisinsk institutt  
Mob: 95227021.

Anne Marte Pensgaard  
Olympiatoppen  
Mob: 41900365



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## Samtykke til deltakelse i studien

Jeg har mottatt skriftlig og/eller muntlig informasjon om prosjektet og samtykker i at jeg deltar i utprøvingen og målingen av effekt av mental trening for høyprestasjonsgrupper. Jeg gir med dette også mitt samtykke til at spyttprøvene mine kan sendes ut av landet for å bli analysert.

Jeg er kjent med at min deltagelse i selve evalueringsdelen av dette prosjektet er frivillig og at jeg når som helst kan trekke meg fra denne delen av prosjektet uten nærmere forklaring.

**Sted/Dato:** \_\_\_\_\_

**Navn m/blokkbokstaver:** \_\_\_\_\_

**Deltakers underskrift:** \_\_\_\_\_

**Jeg bekrefter å ha gitt informasjon om studien**

-----  
(Signert, rolle i studien, dato)



NORGES IDRETTSHØGSKOLE



## APPENDIX II

Approval from the Norwegian Regional Committee for Medical Research Ethics



## Forskningsprosjekt

### Mental Trening og Høyprestasjonsgrupper II

Vitenskapelig tittel:

Prosjekt mental trening av oppmerksomhet for høyprestasjonsgrupper 2010-2015

Prosjektbeskrivelse:

For å kunne anbefale mindfulness trening for høyprestasjonsmiljøer er dette prosjektets hensikt å undersøke om mindfulness trening har effekt på visuell oppmerksomhet, stressrespons og hjernestruktur/aktivitet hos høyprestasjonsindivider. Forskning på normalbefolkningen viser til noen lovende effekter av slik trening, men det er få studier som er gjennomført på individer med allerede høy kognitiv funksjon og med utpreget prestasjonsfokus. Studien vil derfor bidra med kunnskap omkring objektiv og subjektiv effekt samt fremtidig form, innhold tidsbruk på slik trening for optimal måloppnåelse hos høyprestasjonsgrupper.

*(Redigert av REK)*

Ref. nr.: 2011/1679

Prosjektstart: 19.11.2009

Prosjektslutt: 01.08.2015

Behandlingsstatus: Godkjent

Forskningsstatus: Avsluttet

Prosjektleder: [Anne Marte Pensgaard](#)

Forskningsansvarlig(e): [Norges idrettshøgskole](#)

Initiativtaker: Oppdragsforskning

Finansieringskilder:

Driftsmidlene til studie 1 finansieres i sin helhet av Forsvarets Innovasjon, nettverkskapasiteter og informasjonsinfrastrukturstab (INI), avdeling for konseptutvikling og eksperimentering. Forsvarets sanitet v/Flymedisinsk institutt stiller med lønshjemmel til forsker og driftsmidler til studie 2 og 3. Olympiatoppen delfinansierer noe av driftsmidlene i studie 2 og 3.

Forskningsdata: Humant biologisk materiale

Utvalg: Kontrollgruppe(r)

Forskningsmetode: Både statistiske og fortolkende analysemetoder

Antall forskningsdeltakere (Norge): 250

Utdanningsprosjekt/doktorgradsprosjekt: Studium: anvendt idrettspsykologi, Nivå: phd

Materiale fra biobank:

Unifob - stress og helse. Studier om sammenhenger mellom belastning, hvile og helse hos pasienter og vanlige arbeidstakere, i vanlige arbeid og i ekstreme miljøer samt studier om effekt av ulike behandlingsmetoder hos pasienter med subjektive helseplager

**Behandlet i REK**

**Dato REK**

22.09.2011 REK sør-øst

**22.09.2011 REK sør-øst**

**Forskningsprosjekt**  
Mental Trening og Høyprestasjonsgrupper II

**Vurdering:**

I dette prosjektet er formålet å undersøke om egne ferdigheter og valg foretatt under press kan bedres gjennom omfattende øvelser knyttet til mindfulness og bevisstgjøring av svake og sterke sider. Utvalget i studien består av det søker selv definerer som høyprestasjonsgrupper, blant annet helikopter- og jagerflypiloter og toppidrettsutøvere. Det dreier seg med andre ord om toppprestasjoner hos utvalgte grupper i en selvvalgt arbeidssituasjon.

Komiteen har vært i tvil om hvorvidt studien faller inn under bestemmelsene i helseforskningsloven. Man kommer likevel til at resultatene av studien kan ha en viss overføringsverdi også til andre grupper, og at det kan fremkomme funn av medisinsk betydning også for de deltakerne det her gjelder.

Studien er således behandlet av komiteen, jf. helseforskningslovens § 10.

Komiteen opplever at dette er et omfattende prosjekt, hvor det kreves en god del av deltakerne, både med tanke på kursdeltakelse og selvrapportering. I tillegg skal det avgis en rekke prøver underveis. En stor del av utvalget vil være ansatte i forsvaret. De forholder seg således til en kommandolinje, hvor de naturlig vil være underlagt ordre.

Dette gjør det svært viktig at frivilligheten ved deltakelse i dette prosjektet understrekes. Komiteen forutsetter at dette aspektet understrekes både i informasjonsskriv og når informasjon om prosjektet gis muntlig. Frivilligheten gjelder gjennom hele prosjektperioden, slik at dersom noen av deltakerne ønsker å trekke seg underveis i det skisserte opplegget, skal dette respekteres.

**Forskningsbiobank**

Komiteen leser søknaden dit hen at spyttprøvene som samles inn, ikke vil oppbevares i en forskningsbiobank i Norge, men sendes direkte til København for analyse. Dersom det likevel skulle bli aktuelt å opprette en forskningsbiobank i tilknytning til studien, vil dette kreve en søknad til REK, jf. helseforskningslovens § 25.

**Vedtak:**

Prosjektet godkjennes.

Tillatelsen er gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden og protokollen, og de bestemmelser som følger av helseforskningsloven med forskrifter.

Tillatelsen gjelder til 31.12.2015. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato. Prosjektet skal sende sluttmelding på eget skjema, jf. helseforskningsloven § 12, senest et halvt år etter prosjektslutt.

Komiteens avgjørelse var enstemmig.



**UNIVERSITETET I OSLO**  
**DET MEDISINSKE FAKULTET**

I. amanuensis Anne Marte Pensgaard  
Norges idrettshøgskole  
Postboks 4014, Ullevål Stadion  
0806 Oslo

**Regional komité for medisinsk og helsefaglig  
forskningsetikk sør-øst C (REK sør-øst C)**  
Postboks 1130 Blindern  
NO-0318 Oslo

Telefon: 22 84 55 21

**Dato: 31.03.2011**

**Deres ref.:**

**Vår ref.: 2011/559** (oppgis ved henvendelse)

E-post: [post@helseforskning.etikkom.no](mailto:post@helseforskning.etikkom.no)

Nettadresse: <http://helseforskning.etikkom.no>

**Mental trening av oppmerksomhet for høyprestasjonsgrupper**

Vi viser til søknad mottatt til frist 22.02.2011 om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden er blitt vurdert av Regional komité for medisinsk og helsefaglig forskningsetikk i henhold til lov av 20. juni 2008 nr. 44, om medisinsk og helsefaglig forskning (helseforskningsloven) kapittel 3, med tilhørende forskrift om organisering av medisinsk og helsefaglig forskning av 1. juli 2009 nr 0955.

Prosjektleder: Anne Marte Pensgaard  
Forskningsansvarlig: Norges idrettshøgskole

*For å kunne anbefale mindfulness-trening for høyprestasjonsmiljøer, er det dette prosjektets hensikt å undersøke om mindfulness-trening har effekt på kognitiv funksjon, trivsel og stressrespons hos høyprestasjonsindivider. Forskning på normalbefolkningen viser i følge søker lovende effekt av slik trening, men det er få studier som er gjennomført på individer med allerede høy kognitiv funksjon og utpreget prestasjonsfokus. Prosjektet er delt inn i 3 delstudier: 1) Prosjekt mental trening jagerfly (allerede gjennomført), 2) Prosjekt mental trening helikopter og toppidrett og 3) Prosjekt mental trening flyskole og toppidrett. Del 1 av prosjektet ser spesifikt på intervensjonens form og innhold i tilknytning til et jagerpilotmiljø. Del 2 baserer seg på resultatene av del 1, i relasjon til helikopterpilot- og toppidrettsgrupper. Del 3 er basert på erfaringene fra del 1 og 2, og vil danne grunnlaget for et randomisert og kontrollert eksperiment.*

*Prosjektet strekker seg over 12 måneder, med dagsseminar hver tredje uke. Dagsseminarene vil inneholde foredrag, praksis og individuelle samtaler for spørsmål, erfaringer og utfordringer. Mellom seminarene skal deltakerne utføre daglig egentrening.*

Komiteen viser til helseforskningslovens § 4 første ledd, hvor medisinsk og helsefaglig forskning forstås som virksomhet som utføres med vitenskapelig metodikk for å skaffe til veie ny kunnskap om helse og sykdom.

Formålet med dette prosjektet er å skaffe ny kunnskap om hvordan prestasjoner og mestring kan bedres ved utførelsen av bestemte oppdrag eller arbeidsoppgaver. Deltakergruppene må sies å bestå av svært ressurssterke friske voksne, i det det er nettopp stressmestring i forbindelse med krevende yrker som er gjenstand for undersøkelsen.

For å nå dette målet planlegges det å anvende etablerte metoder for å redusere stress og angst. Komiteen mener dette ikke kan sies å være ny kunnskap om helse og sykdom i helseforskningslovens forstand. For deltakergruppen – og for forskergruppen – vil resultatene gi svar i forhold til en valgt normalsituasjon for dem det gjelder.

På bakgrunn av dette mener komiteen at prosjektet ikke fremstår som et medisinsk eller helsefaglig forskningsprosjekt. Det faller derfor utenfor komiteens mandat, jf. helseforskningslovens § 2.

Komiteen merker seg imidlertid at det anføres i søknaden at det kan bli aktuelt å utvide studien til å inkludere måling av stresshormon, immunforsvar, hjerneaktivitet og/eller hjernestruktur. Det gjøres i den forbindelse oppmerksom på at fremtidige utvidelser av studien kan gjøre prosjektet fremleggelsespliktig. I den grad det skal opprettes en forskningsbiobank i prosjektet, skal dette i alle tilfeller søkes REK, jf. helseforskningslovens § 25.

**Vedtak:**

Prosjektet er ikke fremleggelsespliktig, jf. helseforskningslovens § 10, jf. helseforskningslovens §4 annet ledd.

REK antar for øvrig at prosjektet kommer inn under de interne regler for behandling av pasient-/helseopplysninger som gjelder ved forskningsansvarlig virksomhet. Søker bør derfor ta kontakt med enten forskerstøtteavdeling eller personvernombud for å avklare hvilke retningslinjer som er gjeldende.

Komiteens avgjørelse var enstemmig.

Komiteens vedtak kan påklages til Den nasjonale forskningsetiske komité for medisin og helsefag, jf. Forvaltningslovens § 28 flg. Eventuell klage sendes til REK sør-øst. Klagefristen er tre uker fra mottak av dette brevet.

Med vennlig hilsen

Arvid Heiberg (sign.)  
professor dr. med.  
leder

Tor Even Svanes  
seniorrådgiver

Kopi: NIH, Avdeling for forskningsforvaltning og dokumentasjon, postboks 4014 Ullevål stadion, 0806 Oslo

Vi ber om at alle henvendelser sendes inn via vår saksportal:  
<http://helseforskning.etikkom.no> eller på e-post til: [post@helseforskning.etikkom.no](mailto:post@helseforskning.etikkom.no). Vennligst oppgi vårt saksnummer/referansenummer i korrespondansen.

## APPENDIX III

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