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ABSTRACT

Sleep deprivation during military operations can have disastrous consequences on the mission; sleepy soldiers are less efficient and tired officers will quickly lose their ability to make sound judgements. Therefore, the Canadian military, like many others, ought to have a program and guide to help mitigate the effect of the lack of sleep. The Canadian Air Force has a well-established crew rest policy, while the Royal Canadian Navy is always trying to improve their shift working schedule; however, the Army has done very little. In the Canadian Army, only one document touches on the topic of sleep deprivation. The Standing Operating Procedures (SOP) for Land Operations states that soldiers are expected to remain effective for physical tasks for up to three days—72 hours—without sleep. What remains unclear is what the soldiers are expecting or even capable of accomplishing during those 72 hours without sleep. Does this refer solely to physical tasks (trenching digging during defense operations), or can they also accomplish low level surveillance tasks (soldiers in sentry observation posts at the entrance of a camp)? This paper will argue that expecting our soldiers to remain combat effective after 72 hours of sleep deprivation, although possible, will have a severe impact on the mission and the related tasks that they can successfully accomplish. Chapter 1 will provide an overview of sleep deprivation theory, focusing on basic sleep deprivation information and sleep requirement architecture. Chapter 2 will provide a literature review on the effects of sleep deprivation on performance, including decision making, task awareness and physical performance. Chapter 3 will provide a review of other nations' policies with regards to sleep deprivation in comparison of the Canadian Army Policy. The last chapter will focus on recommendations and the way ahead.

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INTRODUCTION

Military campaigns and war have been part of our history since the dawn of time, but as the centuries have passed, military tactics, techniques and equipment have changed and evolved. Today's soldiers use top-of-the-line equipment with the latest technologies as we review and improve the way we conduct military operations. For example, a century ago, there was very little military activity at night, but now with night vision capability we can fight wars both day and night. Over the evolution of military combat, one of the few tangible elements that remain unchanged is the soldier's need for food, water and sleep. We know that our soldiers need water and food to survive and to be able to fight in combat, but the need for sleep is less well understood. The need for sleep is also physiologically based and without it the soldier will not be able to perform optimally.[1] Although the lack of sleep will not kill a person like the lack of water, it remains an essential physical requirement for the optimal functioning of the human body. The following statement from General S.L.A. Marshall during the Normandy attack in 1944 illustrates very well the effect of sleep deprivation and fatigue on the paratroopers and their captain during the last part of the campaign.

> They were dull-eyed, bodily worn and too tired to think connectedly. Even a 30-minute flop on the turf with the stars for a blanket would have doubled the power of this body and quickened the minds of its leaders to ideas which they had blanked out. But no one thought to take that precaution. The United States Army is indifferent toward commonsense rules by which the energy of men may be conserved in combat....Said Captain Patch of his people on the far right, 'They were so beat that they could not understand words even if an order was clearly expressed. I was too tired to talk straight. Nothing I

[1] Nancy J. Wesensten, Thomas J. Balkin, "The Challenge of sleep Management in Military Operations", *The Army Medical Department Journal*, (October-December 2013): 109.

> heard made a firm impression on me. I spoke jerkily in phrases because I could not remember the thoughts which had preceded what I said.[2]

Sleep deprivation can be partial or total, and happens to an individual when the lack of sufficient amounts of quality sleep causes them to experience a circadian rhythm disturbance. It is also important to note that the sleep deprivation count time starts as soon as the soldier wakes up. In other words, if the soldier woke up at 0600 by 2100 he would be considered to have a sleep deprivation of 15 hours.[3]

Various militaries around the world have been studying the relation between the soldier's amount of sleep deprivation and their ability to perform an operation, with the ultimate goal of finding the limit of hours of sleep deprivation at which combat effectiveness declines significantly. The American and Australian armies have both put in place significate sleep management programs to counter the effect of sleep deprivation, as well as educated their members about the importance of sleep.

In the Canadian Army, only one document touches on the topic of sleep deprivation. The Standing Operating Procedures for Land Operations states that soldiers are expected to remain effective for physical tasks for up to three days—72 hours—without sleep.[4] The document in question has only a small table with limited numbers and does not provide any more detailed information and or explanation on the matter. What remains unclear is what the soldiers are expecting or even capable of accomplishing

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[2] Laverne C. Johnson, "The Operational Consequences of Sleep Deprivation and Sleep Deficit, *Advisory Group for Aerospace Research and Development*, Paris (June 1974):3.
[3] Ibid, p.4.
[4] Department of National Defence, B-GL-334-001/FP-001 *Standing Operating Procedures for Land Operation* (Ottawa: DND Canada, 2009), Tam 503-3.

during those 72 hours without sleep. Does this refer solely to physical tasks (trenching digging during defensive operations or building a fence), or can they also accomplish low level surveillance tasks (soldiers in sentry observation posts at the entrance of a camp)? There is also no indication about sleep patterns for those involved in mental work (the chain of command planning the next bound of the operation). Also the standing operating procedures does not provide any evidence that the 72 hours sleep deprivation policy is either suitable or achievable or what the impact on soldiers' performance would be. This demonstrates that the policy needs a significate amount of review and clarification. Also contrary to other nations, the Canadian army does not have a sleep management program or direction for the soldiers and their supervisors. This paper will argue that expecting our soldiers to remain combat effective after and during the 72 hours of sleep deprivation, although possible, will have a severe impact on the mission and the related tasks that they can successfully accomplish.

By conducting a thorough literature review of sleep deprivation effects and prior studies conducted on both civilian and military populations, this paper will demonstrate that after 72 hours sleep deprivation, our soldiers are in fact combat ineffective. The paper will first provide an overview of sleep deprivation theory, focusing on basic sleep deprivation information, sleep requirement architecture and the different stages of sleep. It will next provide an extensive literature review focusing on the effects of sleep deprivation on performance, including decision making, mood, alertness, task awareness and physical performance in field and lab settings. This will be followed by an examination of other nation's policies with regards to sleep deprivation and how they cope and managed the effects of sleep deprivation during operations. The last chapter

will focus on recommendations and the way ahead. It will also include a proposed Canadian sleep management program with an aim of reducing the effect of sleep deprivation and on optimizing combat effectiveness.

CHAPTER 1: SLEEP 101

Introduction

Sleep deprivation during military operations is not a new topic; it has been studied for almost a century. Unfortunately, in this author's view, the Canadian Army, unlike the Royal Canadian Air Force (RCAF) and the Royal Canadian Navy (RCN), has only paid lip service to the impact of sleep deprivation and has not been proactive in creating an effective sleep management program. The Royal Canadian Air Force has a very clear policy on crew rest for its aviators personnel, which is very well detailed in its Flight Safety Manual. Also the RCA has actually reviewed its policy to include crew rest for all personnel directly involved with flight safety, like the avionic technicians that are not currently receiving crew rest. The RCN is currently operating at sea using shift work and is constantly involved with research studies to optimize crew rest and shift work. With all the recent research studies conducted on sleep deprivation, the Canadian Army could benefit from a deeper examination of the current policy and the development of a way ahead with regards to sleep deprivation management. It is with this goal in mind that the author proposes this paper.

Why is this an important topic? Sleep deprivation will impact every soldier at one point or another in their career. From basic training, where the lack of sleep is part of the training, to intense combat missions, lack of sleep will affect the outcome. Understanding the consequences of sleep deprivation will help the chain of command in managing their own tempo to minimize the negative impact. But in order to be able to do that, the chain of command at every level from the course officer to the Joint Task Force Commander should have available to them clear guidelines and directives that have been reviewed and

conform with today's standards. Therefore, a review of The Standing Operating Procedures for Land Operations stating that soldiers are expected to remain effective for physical tasks for up to three days—72 hours—without sleep needs to be conducted.

To review the current army guideline on sleep deprivation and to develop a sleep management guideline, a literature review of sleep studies both in laboratory and field settings will be conducted. This will be followed by a review of some of our allies' policies in comparison with our own policy. The paper will culminate with the development and recommendation of a new policy. But first, sleep and sleep deprivation must be understood.

To be able to fully explain the impact of sleep deprivation on soldiers during operations, a very good understanding of the science of sleep, its effect on the body and the theory behind sleep deprivation is a prerequisite. As this paper will talk extensively about sleep, sleep deprivation and fatigue, it is important to fully define the basic terminology. For this paper the following definitions will be used. Sleep is defined as "An unconscious state regularly and naturally assumed, which is characterized by an almost complete absence of movement and reduced sensory awareness, and during which both mental and physical recuperation take place"[5]. Sleep deprivation occurs "when an individual gets no sleep during the normal sleep/wake cycle."[6] Finally, fatigue is "a state of weariness caused by physical and/or mental exertion."[7] This chapter will provide information on; basic sleep background, sleep requirement, sleep deprivation and

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[5] Australian Defence Force, *Fatigue Management During Operation: A Commander's Guide*, (Department of Defence (Army) Australia, 2002): xiv.
[6] Kelli Westcott, "Modafinil, Sleep Deprivation, and Cognitive Function in Military and Medical Settings", *Military Medicine* (170, 2005):333-337.
[7] Australian Defence Force, *Fatigue Management During Operation…,* xiii.

impact/consequences of sleep deprivation to explain why we need sleep and how crucial it is for every human being.

Basic Sleep Information

Sleep has been studied for centuries and is very well documented; however, there remains uncertainly about the need of sleep and what actually happens when we sleep. Contrary to popular belief, sleep is not a state of inactivity, it is actually a very busy time for our brain and body (including hormone secretion, but this is beyond the scope of this paper)[8]. The following section will provide an overview of some basic facts about sleep in terms of sleep architecture, stages of sleep, dreams and nightmares, circadian rhythm, rest and nap, sleep inertia and jet lag. This will provide the necessary background information on sleep in order to better understand the numerous research studies conducted on sleep deprivation and explain the reasoning behind the development of the future sleep management program.

Sleep architecture

As mentioned above, there was a time where it was believed that our brain was "sleeping" during our sleep, but scientists now recognize that our brain while asleep is sometime more active than while we are awake.[9] The consensus is that the human brain has two types of sleep cycle: rapid eye movement (REM) and a non-rapid eye movement

[8] Ibid, 2.
[9] Nita Lewis Miller, Panagiostis Matsangas, Aileen Kenney, "The Role of Sleep in the Military: Implication for Training and Operation Effectiveness." Naval Postgraduate School, Department of Operational Research, (2011):5.

(NREM) periods.[10] The NREM is further divided into four stages. For optimal functioning, our soldiers need adequate amounts of sleep in both the REM and NREM. [11]

Stages of sleep

Using an electroencephalogram **(**EEG), electromyography **(**EMG**)** and electrooculography researchers Rechtscaffen and Kales (1968) were able to determine that the human sleep during the NREM progresses through 4 distinct stages.[12] Lasting only a few minutes, stage 1 is characterized by a reduction of muscle tone and by a rather slow rolling eyes movement. Also, during that stage the soldier is vaguely aware of his or her surroundings[13,14]. Lasting between 30 to 60 minutes, stage 2 is where the actual sleep begins; in this stage there is no eye movement and a further reduction in the muscle tone can be observed.[15] Stage 3 is characterized by a deeper sleep, the body core temperature decreases, metabolism slows down and hormones are secreted. The final stage is the deepest sleep, when we heal and recover. Following stage 4, the sleep moves into the REM phase.[16] As previous mentioned, the REM phase is characterized by rapid eye movement and an absence of muscle tone. The first period of REM lasts only a few minutes and moves into a progression from stage 2 to 4, before going back into another REM phase. This is what we call a full cycle of sleep and it usually lasts from 90-110

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[10] N.L. Miller, P. Matsangas, L.G Shattuck, "Fatigue and its Effect on Performance in Military environments, *Performance under Stress* (2007) 234.
[11] Ibid, 235.
[12] Gidugu Himashree, P.K. Banerjee, W. Selvamurthy, "Sleep and Performance-Recent Trends", Indian Physiol Pharmacal, (2002):8.
[13] Gidugu Himashree, *Sleep and Performance-Recent Trends,*8
[14] Y Hou, E Huangfu, L Zhang, D Mioa, "Changes in Cognition and Moral Due to Sleep Inertia After 30-hour Sleep Deprivation. *The Internet Journal of Mental Health,* Volume 4, no.1 (2006): 3.
[15] Gidugu Himashree, *Sleep and Performance-Recent Trends,*8.
[16] Y Hou, *Changes in Cognition and Moral…*, 3.

minutes. As seen in figure 1.1, a good average night of sleep of 8 hours will have on average 4 to 6 cycles with the last REM lasting about 60 minutes.[17] It is important to note that REM sleep is essential to improve and sustain memory storage, retention and mental performance.[18]

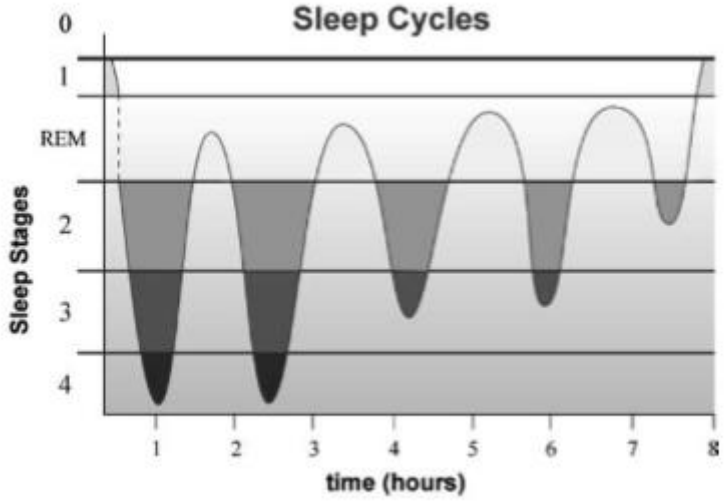

Figure 1.1 Sleep cycles over a typical 8-hour sleep[19].

Dreams and nightmares

Most dreams and nightmares occur in the REM phase of the sleep cycle and account for about 20 to 25 % of total sleeping time.[20] Dreaming is essential for our mental well-being, and studies have shown that those who are prevented from dreaming will develop symptoms of mental disturbance in the days following the lack of dreams. (This can also be observed during sleep deprivation torture.)[21] All humans dream every night

[17] Gidugu Himashree, *Sleep and Performance-Recent Trends,*8
[18] Y Hou, *Changes in Cognition and Moral…*, 3.
[19] N.L. Miller, "Fatigue and its Effect on Performance…, 234.
[20] Australian Defence Force, *Fatigue Management During Operation…,*6.
[21] Jeff Mann, "A Brief History of Sleep Deprivation and Torture" in Sleep Junkies, 25 Oct 2012.

but not everybody remembers their dreams in the morning. Nightmares are also commonly experienced by soldiers returning from a difficult mission or operation. A study demonstrated that 59% of American Vietnam combat veterans experience at least monthly nightmares.[22]

Circadian Rhythm

The circadian cycle plays an essential role in our sleep pattern. The word circadian originates in the Latin *circa* 'around' + *dies* 'day' and is defined as "A biological process recurring naturally on a twenty-four-hour cycle, even in the absence of light fluctuations."[23] Humans are diurnal creatures, and our circadian rhythm programs us to be awake and active during the day and to be asleep for 8 hours per night.[24] Studies have demonstrated that without light and other temporal factors, most human have an internal 24.5 to 25 hour clock, but with our lifestyle, exposure to light, exercise, social interaction and meals, we have adapted to the 24 hour cycle.[25] Researchers agree that the circadian low point, at which the individual is less effective and alert is between 0200-0600 hours and the circadian high where we are the most alert (better for physical performance) is between 1400 and 2000 hours. In accordance with studies on circadian rhythm, the best time to perform mental work and memory processing is between 0800-1200 hours.[26] Figure 1.2 shows the soldier's level of performance in reference to the circadian rhythms,

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[22] Australian Defence Force, *Fatigue Management During Operation…,*7.
[23] Online Oxford Dictionary.
[24] P. Naitoh, T. L. Kelly, "Sleep Management User's Guide for Special Operations Personnel". *Naval Health Research Center*, Report no.92-28 (1992), 8.
[25]N.L. Miller, "Fatigue and its Effect on Performance…, 232.
[26] G. C. K. Giam, "Effects of Sleep Deprivation with Reference to Military Operations" *Ann Acad Med Singapore* (1997): 1.

showing a low performance during the hours of the low circadian rhythms.[27] This will be critical to fully understand our soldiers' effectiveness in a 24-hour cycle.

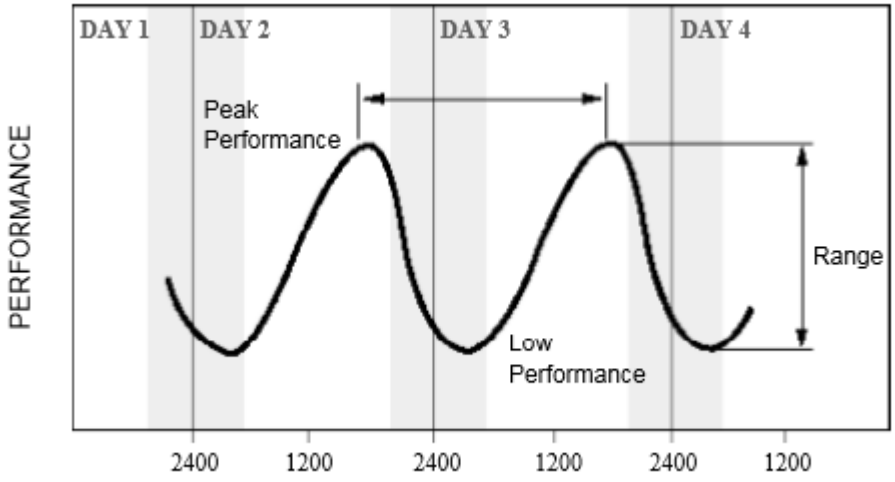

Figure 1.2 Circadian Rhythms over a 4-day period.[28]

Rest and nap

Sleep periods taken during the day are less effective and recuperative than the same amount of sleep taken at night; this is in part due to the circadian rhythm.[29] Also sleep is more beneficial if it is taken during a continuous period versus multiple shorter periods. For example, 8 hours of continuous sleep will be better than 2 four-hour naps even if the total amount is the same. Even though taking naps may interfere with sleeping at night, if the operational situation does not allow for a night of sleep, multiple naps of at least 20 to 40 minutes will tremendously help to reduce the effects of sleep deprivation.[30]

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[27] U.S. Naval Strike and Air Warfare Center, "Performance Maintenance during continuous Flight Operations- NAVMED P-6410", January 2000: 5.
[28] *Ibid*, 5.
[29] G. C. K. Giam, *Effects of Sleep Deprivation…*, 2.
[30] P. Naitoh, *Sleep Management User's Guide for Special Operations Personnel*, 5.

Resting by lying down with our eyes closed does not have any of the benefits of sleep or naps; it cannot replace the body's need for sleep.[31]

Sleep inertia

Sleep inertia is defined as "a period of transitory hypovigilance, confusion, disorientation of behavior, and impaired cognitive and sensory-motor performance that immediately follows awakening."[32] The process of transition from sleep to wakefulness is a very complex process, and our body and brain need time to adjust from one state to the other.[33] The degree of sleep inertia (severity and duration) a person experiences will increase if they are in a situation of sleep deprivation. Sleep inertia varies for each individual, but it is generally short, lasting 1 to 20 minutes. Sleep inertia can impact soldiers on operations: if they are called to react immediately to a threat/enemy after waking up or being woken up from sleep, they may not perform at their optimum for the first few minutes. Studies also demonstrated that sleep inertia is worse during the circadian low cycle.[34] In addition, an unusually long period of sleep (10-12 hours) may increase the sleep inertia period. [35]

Jet Lag

Often our soldiers, to accomplish their duty, are asked to travel across multiple time zones. In order to understand the limitation of the soldier upon arrival in new time

[31] G. C. K. Giam, *Effects of Sleep Deprivation…*, 2.
[32] Y Hou, Changes in Cognition and Moral…,1.
[33] Ibid, 1.
[34] G. C. K. Giam, *Effects of Sleep Deprivation…*, 88.
[35] Ibid,89.

zones, the effects of jet lag must be better understood. The term jet lag refers to the de-synchronisation of the internal clock with the local time. [36] It is widely accepted that on average, it takes one day for each time zone crossed, to fully recover from the jet lag effect. Until full recovery, the soldier may experience low energy, sleepiness during the day, wakefulness at night, irritability and overall performance diminution.[37]

Having a good understanding of the basics of sleep is crucial to understanding sleep deprivation. The sleep cycle and the stages of sleep including the REM are vital for a recuperative sleep period, and they are also responsible for our dreams and nightmares. Sleep architecture is also regulated by the circadian cycle and explains why most soldiers will have a difficult time staying awake in the middle of the night.

Sleep requirement

Researchers don't necessary agree on how much sleep we should get. The reason is quite simple: sleep, like the amount of food we need to eat, is an individual requirement. Every soldier is different and they all require a different amount of sleep to be functional. Various factors can affect the individual's need for sleep: age, gender, type of employment and level of physical fitness. However, most researchers agree that the adult individual's need for sleep is in the range of 8 hours per night.[38] The literature agrees that some individuals need significantly more or less sleep than the average, and its just part of human nature.[39] Those individual require more hours of sleep to be at the

[36] Ibid 90.
[37] P. Naitoh, *Sleep Management User's Guide for Special Operations Personnel*, 10.
[38] N.L. Miller, "Fatigue and its Effect on Performance…, 233.
[39] Michele Ferrara, How much sleep do we need? 18.

same level of "freshness" as the average individual. Two factors age and gender will be discussed to explain the sleep requirement.

Age and sleep

Age plays a big factor in the need for sleep, and over our lifespans the need for sleep will dramatically change. Newborns and infants need lots of sleep for the first few weeks; they spend most of their days sleeping and as they get older, their need for sleep will diminish to stabilize at around 8 hrs per night as they reach adulthood (mids-20s). This need will remain stable for a few decades before changing when they reach the golden age (60-70). It is very common for soldiers to join the military in their late teens or as young adults. At that age bracket (16-25), the soldiers are still physically developing and their need for sleep is a bit higher. The recommended time is from 8.25 to 9.25 hours per night. It is important to note that most of our recruits fall into this category of sleep requirement. [40] Figure 1.3 represents a typical sleep pattern over a lifespan from infancy to adulthood, but the golden age is not represented in the graph.

[40] N.L. Miller, "Fatigue and its Effect on Performance…, 232.

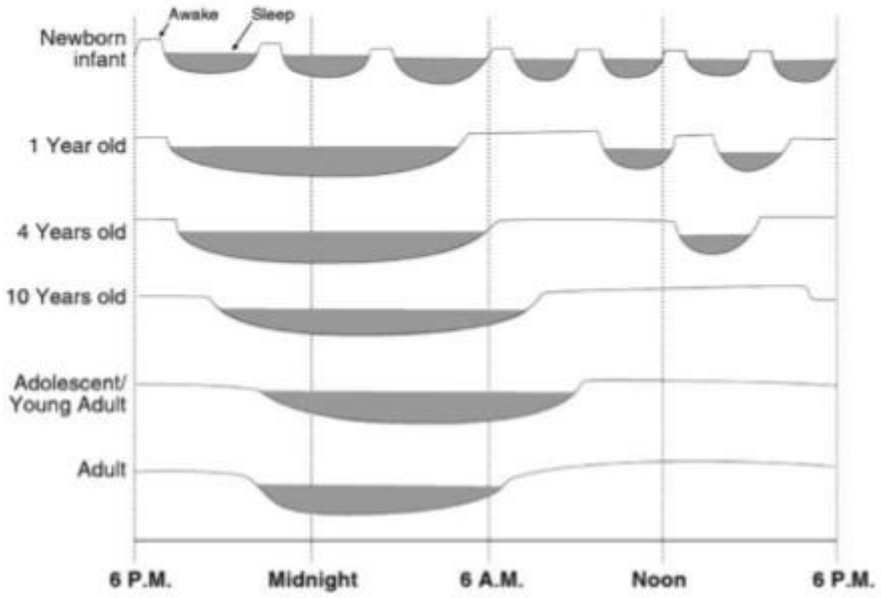

Figure 1.3 Sleep patterns over the lifespan.[41]

Gender and sleep

Anatomically, functionally and hormonally males and females have specific differences, so there is no surprise that the requirement for sleep is also gender specific. Studies have shown that the effect of sleep deprivation is milder for women, allowing them to cope better than men under sleep deprivation conditions[42] However, studies have also demonstrated that women have a greater need for core sleep (individual sleep requirement to be fully functional the following day) than men, with self-reporting studies showing women sleeping longer periods than men, and going to bed earlier than men.[43]

[41] N.L. Miller, Panagiostis Matsangas, Aileen Kenney, "The Role of Sleep in the Military: Implication for Training and Operation Effectiveness." Naval Postgraduate School, Department of Operational Research, (2011): 4.
[42] Jolanta Orzel-Gryglewska, "Consequence of Sleep Deprivation" International Journal of Occupational Medicine and Environmental Health (2010;23): 106.
[43] Michele Ferrara, How much sleep do we need? 16.

This concludes the section on sleep requirements; sleep is an individual need and varies from individual to individual with regards to age, gender and previous experience; however, most soldiers will require an average of 7-8 hours of sleep per night to be effective.

Sleep deprivation

Sleep deprivation can be divided into two categories: total and partial. Total sleep deprivation is defined as no sleep for at least 24 hours, and partial is defined as an amount less than the "usual" amount of sleep a soldier gets (shorthand: less than optimal sleep time), and varies from individual to individual.[44] Some researchers believe that "with special and prolonged training, some individuals can learn to tolerate about three hours of sleep per 24 hours, for short periods; without major deleterious effects."[45] Figure 1.4 provides a good overview of several types of sleep deprivation and insomnia due to lifestyle, work and other factors like medications.[46]

[44] G. C. K. Giam, *Effects of Sleep Deprivation…*, 88.
[45] Ibid, 91.
[46] N.L. Miller, *Fatigue and its Effect on Performance*…", 1.

Types of sleep reduction	Causes	Comments/examples
Commonly observed reduction in sleep time	Daily sleep time reduction below the level of optimal individual needs	Sleep time reduction is a common phenomenon resulting from contemporary lifestyle
	Single omission of night sleep (24-h wakefulness)	Being on duty at work, taking care of an ill person, partying
	Shifting sleep period in relation to the circadian pattern (shift work)	In shift work, the sleep time is not concordant with the biological rhythms and is usually shorter than that of the natural sleep. In air travel, rapidly changing the time zones results in the jet-lag syndrome
Considerable reduction in sleep time	Wakefulness prolonged to several days	Experimental conditions, extreme situations (e.g. tortures), tribal shamanic rites
	Selective deprivation (only REM or 4-NREM sleep)	Experimental conditions, with polysomnographic assessment of the sleep stages and phases
	Total sleep deprivation (extreme prolongation of wakefulness)	Only in experimental animals; the rats die after 16–21 days of sleep loss on average, other species show lesser disruption in functioning after a comparable sleep loss
Sleep reduction (insomnia) due to pathological processes	Depression, anxiety disorders	In these disorders, the shallow sleep is delayed and shortened, not providing enough rest
	Addiction (medications, alcohol)	Insomnia is one of the symptoms of physical addiction; paradoxically, continuous intake of sleep-inducing medications makes the sleep pill-dependent; alcohol suppresses the REM sleep
	Somatic, mainly painful diseases	Restless leg syndrome, sleep-related breathing disorders and certain metabolic diseases (thyroid hyperactivity)
	Primary sleep disorders: idiopathic, psychophysiological and subjective insomnia	The causes: genetic determinants intensified by old age and improper sleep hygiene; chronic stress, traumatic experience, difficult life situations; inadequate subjective assessment of the duration and quality of one's sleep

Figure 1.4 Type of sleep deprivation and the cause of insomnia.[47]

Acute versus Chronic

Furthermore, sleep deprivation can be acute (short term) or chronic (long term). A soldier missing one night of sleep (acute sleep deprivation) would return to normal as soon as the soldier has had a good night's sleep, gaining full recovery after 2 days with no significant symptoms. Chronic sleep deprivation happens when the soldier is on

[47] N.L. Miller, *Fatigue and its Effect on Performance*…, 1.

operation (high tempo and limited time for rest) and is suffering from sleep deprivation during a long period of time. If the soldier is unable to make up their sleep debt, after a few days' symptoms of chronic sleep deprivation will appear. Those symptoms may include irritability, cognitive impairment, memory lapse and many more. This will be discussed in detail in the next chapter.[48]

Impact/consequences of sleep deprivation

Researchers have studied the effects of sleep deprivation since the nineteenth century, with the first attempt to study the effects of long-term sleep deprivation conducted in 1896.[49] Although the next chapter will extensively cover the impact and consequences of sleep deprivation both from a military and civilian perspective, this section will provide a short overview of the following aspect of sleep deprivation; micro sleep, long term impact and the effects on the body and brain.

Micro sleep

Micro sleeps are brief period of involuntary or unintended sleep, lasting only a few seconds; anyone affected by sleep deprivation can have micro-sleep episodes. Even the most motivated soldier can be affected by them. Micro sleep can result in serious accidents; for example, if a sleep deprived driver has a micro sleep episode while driving, it can have catastrophic results.[50] Research using polygraphed analysis has shown that with a sleep deprivation of 72 hours and above, it is impossible to prevent the soldier

[48] Michele Ferrara, *How much sleep do we need*? 3.
[49] Ibid, 95.
[50] Laverne C. Johnson, "The Operational Consequences of Sleep Deprivation and Sleep Deficit, Advisory Group for Aerospace Research and Development, Paris (June 1974):1-47.

from experiencing micro-sleeps. The micro-sleeps are considered equivalent to stage 1 of the sleep cycle with regard to the periods of drowsiness and perception.[51] Some studies refer to the micro sleeps as sleep attacks.[52]

Long term impact of sleep deprivation

Being in a state of prolonged sleep deprivation is very difficult mentally and physically, but research has shown that it will not kill. The longest period of sleep deprivation in a study was 266 hours, and the 17-year-old withstood the deprivation well; the primary conclusion was that a long period of sleep deprivation was relatively harmless to the person's long term health.[53]

Effect of sleep deprivation on the body and brain.

This paper will focus on the effect of sleep deprivation on different areas: alertness, basic cognitive function, mood and physical function. The physical aspect of sleep deprivation can be seen in the decrease of tonus and posture. In addition, maintenance, speech deterioration and reduction in physical exercise capacity are all results of sleep deprivation. The mood aspect can be seen in the increase of irritability, reduction of patience and overall happiness. Cognitive impairment "occurs when problems with thought processes occur. It can include loss of higher reasoning,

[51] Johnson, The Operational Consequences of Sleep Deprivation and Sleep Deficit, 4.
[52] Julian Lim, David F, Dinges, "Sleep Deprivation and Vigilant Attention" in Department of Psychology, University of Pennsylvania, Pennsylvania, (USA, 2008): 311.
[53] G. Gulevich, Dement W, Johnson L, "Psychiatric and EEG observation on a case of prolonged (264 h) wakefulness. Arch Gen Psychiatry (Vol 15, 1966) 29-35.

forgetfulness, learning disabilities, concentration difficulties, decreased intelligence, and other reductions in mental functions."[54]

Conclusion

From a military leadership perspective, the key takeaways from the science of sleep and the theory behind sleep deprivation are: 1) a soldier requires 7-8 hours of good sleep every 24 hours to be fully effective, but some soldiers may need more or less sleep. 2) Sleep in accordance with the circadian cycles (i.e. at night) is more effective than sleep during the day. 3) Even your best soldier will experience episodes of involuntary micro sleep during an extended period of sleep deprivation. 4) A soldier's performance (mentally and physically), mood and alertness will be affected by the lack of sleep. 5) A soldier will experience sleep inertia for 1-20 minutes after they first awake, and longer if they are sleep deprived. The following chapter will provide a literature review of the studies available to better understand the limits of what a soldier can and cannot do under a condition of sleep deprivation.

[54] http://www.healthgrades.com/symptoms/cognitive-impairment

CHAPTER 2: LITERATURE REVIEW

Introduction

As new technology emerges and improves our productivity, the weakest link in production has become the human factor. Even though most industries can run for 24 hours per day, they are limited by the ability of human beings to perform around the clock. Militaries around the world are facing the same situation; they have the technology to fight 24 hours per day, but the soldiers can't keep up this pace. In order to understand why the productivity of industries varies during the 24-hour cycle (especially during the night shift) or to understand why soldiers are no longer effective after a certain amount of time, studies have been conducted in both military and civilian settings over the last century. Today we can draw upon the results of those various studies to better understand how our soldiers will react under certain sleep deprivation conditions. First, a literature review of the physical effects of sleep deprivation and its effect on decision making will be conducted. But the main focus of this chapter will be on the review of military studies conducted during sustained and continuous performance during operations and /or training. This chapter will conclude with the expected syndrome/consequence for sleep deprivation in a military context. However, this chapter will start with the origin of the first study, followed by the criteria used for this literature review and although briefly discussed in chapter 1, the symptoms of sleep deprivation will be reviewed in more detail. The section will then conclude with a correlation between alcohol consumption and sleep deprivation.

Origin of the first study

As previously mentioned in chapter one, the first attempts to study the effects of long-term sleep deprivation were conducted in 1896, when three Americans were studied during a 90-hour sleep deprivation period. During this period, one of the volunteers suffered hallucinations. Almost 60 years passed before the first studies of intense sleep deprivation (over one week) were conducted in the 1960s.[55] Those studies were instrumental in understanding the effects of sleep deprivation during sustained or continuous periods, like those faced by our soldiers in operations and training. Since then, each decade brought its share of new studies and new way to mitigate those effects, some pharmacological and some non-pharmacological, such as a better sleep management program. The latter part will be discussed in detail in the last chapter. This chapter will focus on the study itself and the result and its application to the military community around the world, and especially our Canadian Army.

Criteria for literature review

Given the evolution in the academic literature on sleep research, only studies between 1960 and 2015 were consulted. The studies chosen were ones in which cognitive ability (including decision making and vigilance) and physical abilities were discussed. The author acknowledges that numerous studies of sleep deprivation in relation to other domains such as neurologic (changes in brain structure activities), biological (immune system implication) and mental function (manic symptoms) have been conducted, but they were deemed to be outside the scope of this paper. Also only the studies that were

[55] Jolanta Orzel-Gryglewska, Consequence of Sleep Deprivation, 95.

performed using a baseline reference and which detailed experimental conditions were selected.[56]

Symptoms of sleep deprivation.

What are the common symptoms of sleep deprivation? Do researchers agree on common generic symptoms? Although not all studies done in the past few decades use these generic symptoms for sleep deprivation, the most widely agreed upon symptoms of sleep deprivation are those presented by Dr. S. Coren in an article published in the Psychiatric Times in 1998. Figure 2.1 presents a tabulated version of what symptoms we can expect a person to experience each day of sleep deprivation.[57] Those symptoms are very generic and a more thorough literature review is needed to truly understand those effects on our soldiers in continuous operations with minimal sleep or none at all. Nonetheless, this table will serve as a baseline to understand the basic effects on the general population.

[56] Stefan Lauthenbacher, Kundermann Bernd, Kieg Jurgen-Christian, "Sleep deprivation and pain perception", *Sleep Medicine Reviews* (Vol 10, 2006): 357-369.
[57] S. Coren, "Sleep deprivation, psychosis and mental efficiency," Psychiatric Times (Vol 15, 1998):1.

Duration of sleep deprivation	Symptoms
Night 1.	Most people are capable of withstanding one-night sleep deprivation, although a slight discomfort may be experienced. 24-h sleeplessness does not alter behaviour; however, tremor and increased tonus, leading to impairment in precise movements, can be observed.
Night 2.	A feeling of fatigue and a stronger need for sleep is persistent, especially between 3 a.m. and 5 a.m., when the body temperature reaches its lowest value.
Night 3.	Performing tasks that require concentration and calculating may be impaired, particularly if the tasks are dull and repetitious. The volunteers become irritated and impolite in any instance of disagreement. During early-morning hours, the subjects experience an overpowering need for sleep. Remaining wakeful is possible only with the help of the observers who wake the volunteers up if necessary.
Night 4.	Prolonged microepisodes of sleep occur: the subjects discontinue their activities and stare into space; the delta waves are recorded in the EEG output signal, even if the person is awake. Sleep microepisodes impair performance of the tasks that require attention over a period of time. Subjects may also experience perception disorders, illusions, hallucinations, irritation, inaccuracy and the 'hat phenomenon' (a feeling of pressure around the head).
Night 5.	The symptoms become more intense and include disturbances in reasoning and orientation, visual and tactile hallucinations, fatigue, irritability and delusions. The subjects may exhibit distrust: suspecting that someone attempts to murder them is a characteristic syndrome at this stage. Intellectual and problem-solving abilities are considerably impaired.
Night 6.	Participants develop symptoms of depersonalization and they are no longer capable of interpreting reality. This syndrome is known as the sleep deprivation psychosis (very rarely persisting after the termination of the experiment; it usually subsides after a sufficient time of sleeping).

Figure 2.1 Symptoms observed during consecutive nights of sleep deprivation.[58]

Social aspects of sleep deprivation and fatigue

In the previous chapter it was mentioned that no human death has ever been attributed directly to sleep deprivation; however, insufficient sleep (or lack of sleep) has been the indirect cause of numerous incidents/accidents. The obvious example is the number of traffic fatalities due to sleepiness or falling asleep at the wheel. The AAA (Automobile Association of America) estimates approximately 69,300 deaths (16.5% of total traffic fatalities) from 1999 to 2008 were due to sleepiness.[59] Those traffic accidents and accidents at home and at work due to the lack of sleep also have an economic impact on our society. Industries are also faced with increased costs due to inefficiency caused

[58] Ibid, 1.
[59] Wesensten and Balkin, The Challenge of sleep Management in Military Operations, 109.

by sleep-deprived personnel. Therefore, understanding the importance and impact of sleep has become a worldwide concern and issue.

In this day and age, the general population understands very well the impact of drinking and driving. Most countries, including Canada, have a very strict policy when it comes to the legal limits of blood alcohol concentration for drivers. However, no such rule or understanding exists for an individual in a state of sleep deprivation behind the wheel of a motorized vehicle. In generic terms, a person under the influence of alcohol and one experiencing sleep deprivation have the same effects: reduced vision, impaired attention, slower reflexes, and reduced performance.[60] A study conducted by Williamson demonstrated that "moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally proscribed levels of alcohol intoxication."[61] In this study, performance of transport industry members and US army soldiers was first measured after a 28 hour sleep deprivation period and later (after a rest period) after measured doses of alcohol up to approximatively 0.1% blood alcohol concentration. According to this study, after 17 to 19 hours of sleep deprivation, performance was equivalent to or worse than the test with a BAC of 0.05%. Speed of response was also slower in the sleep deprivation test versus the BAC test (sometime more than 50% slower). After a longer period of sleep deprivation (22-24 hours), performance was equivalent to or worse than a BAC of 0.1%.[62] Other studies have also demonstrated that

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[60] US Department of Defense Congressionally Directed Medical Research Programs, "Researcher Studies Sleep Deprivation's effect on decisions" (Public release: 7-Aug-2006): 1.
[61] A. M. Williamson, Anne-Marie Feyer, "Moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication", *Occup Environ Med* (Vol 57, 2000): 649.
[62] Ibid,649.

sleep deprivation is the equivalent of .5-1% level of blood alcohol concentration.[63] Even though their performance is worse than the maximum BAC permitted by law, a person under sleep deprivation conditions is still allowed to take to the road and most people do not realize the potential catastrophic implications.

Effect of sleep deprivation on performance

Sleep deprivation will have effects and or impacts on soldiers' performance, and those effects can be seen in the alertness, cognitive performance and the mood of the soldiers. The following section will look at the relationship between performance and the impact of a daily nap. Also, the mental work declination and lost sleep degradation will be quantified.

Mental work ability

The literature is very well documented in the area of mental work and performance during sleep deprivation periods. It is generally accepted that the ability to conduct mental work declines by 25% per each day of sleep deprivation; in other words, after 48 hours' sleep deprivation, the mental ability of the senior leadership of our the military forces would only be at 50% of their total capability.[64] Those result were made available by the Walter Reed Army Institute of Research from cognitive performance

[63] Jolanta Orzel-Gryglewska, Consequence of Sleep Deprivation, 107.
[64] Gregory L. Belenky, Krueger, Gerald P.; Balkin, Thomas J.; Headley, Donald B.; Solick, Robert E., "Effects of Continuous Operations (CONOPS) on Soldier and Unit Performance: Review of the Literature and Strategies for Sustaining the Soldier in CONOPS", *Walter Reed Army Institute of Research* (1988): 1-4.

studies using a variety of computer-based tests during 72 hours' sleep deprivation.[65] Augus and Heslegrave, also demonstrated that the military cognitive tasks (i.e. command and control duties) decreased about 30% after the first 24 hours without sleep and reached about 60% of baseline at the 48 hour mark.[66]

Impact of daily nap

In order to mitigate the effects of cognitive performance degradation (especially the mental work discussed above) during long periods of sleep deprivation, the United States Army Medical Research and Material Command (US AMRM) conducted an 85-hour sleep deprivation study, but allowed the subjects to take a daily 30 min nap. The result (as seen in figure 2.2) using a speed-accuracy % baseline, shows that even a small amount of daily sleep can reduce the rate of performance degradation. Short naps also have a positive impact on the soldiers' mood. A study done by Hou (2006) suggests that a nap during a 30 hours' sleep deprivation period improves the positive moods of the subjects.[67] Although their moods improve, it did not affect their individual baseline standard.

[65] Grey Belenky, David M. Penetar, David Thorne, Kathryn Popp, John Leu, Maria Thomas, Helen Sing, Thomas Balkin, Nancy Wesensten, and Daniel Redmond. "The effects of sleep deprivation on performance during continuous combat operations." *Food components to enhance performance* (1994): 127-135.
[66] Stephen Flanagan, "Losing Sleep" in ArmedForcesJournal (1 Dec 2011): 2.
[67] Y Hou, Changes in Cognition and Moral…, 1.

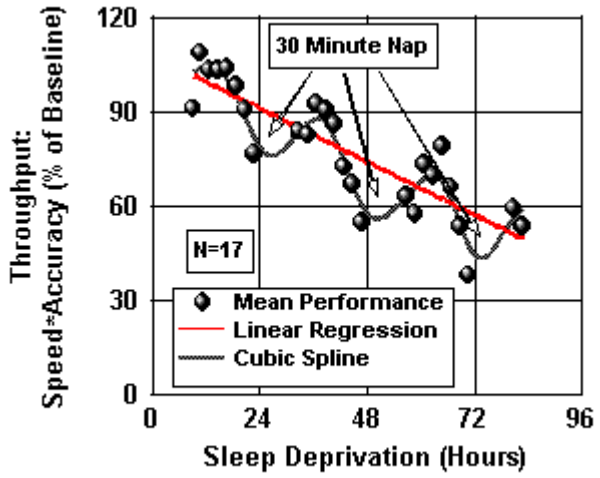

Figure 2.2 85 Hours of Sleep Deprivation: Performance on Serial with Daily 30 Min Nap.[68]

To summarize, the ability to conduct mental work declines by 25% per each day of sleep deprivation; therefore, after 72 hours' sleep deprivation the mental reasoning of a soldier would be at 25% of overall capacity or in other terms, the mental ability would have declined by about 75%. However even a small amount of rest, as demonstrated by a 30-minute nap can reduce the rate of performance degradation.

The effects of fatigue and sleep deprivation in operational environments

The US Army Center for Combat Readiness has been studying the effects of fatigue and sleep deprivation during military operations. Their numerous studies reveal that under prolonged wakefulness periods, soldiers can and will experience the following:

[68] Gregory, COL Belenky, "Sleep, Sleep Deprivation, and Human Performance in Continuous Operation" in *Walter Reed Army Institute of Research, (1997): 9.*

> "difficulty in thinking clearly; poor performance; greater tolerance for error; inattention to details; increased lapses of attention; increased irritability; decreased motivation, attempts to conserve effort; increased errors; slow and irregular reaction times; impairment in communicating and cooperating with other soldiers, headaches or stomach-aches; poor morale."[69]

The following section will look at the various military studies conducted in order to validate and better understand the previous declaration from the Army Center for Combat Readiness. First, the US Army Ranger School Studies will provide information on cognitive performance and droning during long periods with minimal sleep. The Navy Seal candidates study will discuss accuracy in target shooting and marksmanship. The correlation between rank and level of headquarters will be demonstrated with the National Training Center studies. Finally, the ability to sustain situational awareness in sleep deprivation conditions will be validated with the studies conducted at the Artillery Fire Direction Center.

US Army Ranger School Studies

One of the pioneer studies of sleep deprivation in almost continuous military operation is the series of studies conducted during the Rangers' training at the US Army Ranger School. The study of one serial of the 58-day course, involving light infantry operation against a simulated superior force, indicated that the students averaged 3.2 hours of sleep daily.[70] During the subsequent studies of two more classes, the average was 3.6 hours. It should also be mentioned that the sleep was not taken during a single period,

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[69] Chris Johnson, "The systemic Effects of Fatigue on Military Operation", *Department of computing Science, University of Glasgow*, (2012): 3.
[70] Gregory, COL Belenky, Sleep, Sleep Deprivation, and Human Performance…, 2.

but during multiple naps over the course of a 24-hour period.[71] Interestingly the result in cognitive performance in the candidates was marginal and they experienced frequent periods of "droning", meaning that they were still able to walk and respond to challenges but showed great difficulty in understanding the situation around them and in taking actions upon their own initiative.[72] Some researcher have suggested that their cognitive response and overall performance remained stable after the first week of sleep deprivation, raising some arguments that a response to the "sleep deprivation effect" can be learned and loss of sleep mitigated with long and intense training with consistent sleep deprivation.[73] There is reason to believe that those soldiers would perform better during intense war situations than soldiers with no prior sleep deprivation training.

Study of Navy SEAL candidates[74]

The Navy SEAL Hell Week training has also been the venue for studies on sleep deprivation. The study examined the effect of 72-hour sleep deprivation. The study also looked at the caffeine effect on performance, but this topic will be discussed later. For now, the focus will be on the effects demonstrated by the Navy Seals, after sleep deprivation. The study compared results from baseline data (taken one week prior) and the data after 72 hours, which showed that there is a significate decrease in the accuracy of shooting. Indeed, there is a 37.5% increase in missed targets, 38% increase in the

[71] Grey Belenky, David M. Penetar, David Thorne, Kathryn Popp, John Leu, Maria Thomas, Helen Sing, Thomas Balkin, Nancy Wesensten, and Daniel Redmond. "The effects of sleep deprivation on performance during continuous combat operations." Food components to enhance performance (1994): 2.
[72] Gregory, COL Belenky, Sleep, Sleep Deprivation, and Human Performance…, 2-3.
[73] Ibid, 4.
[74] H.R. Lieberman, Niro P, Tharion WJ, Nindl BC, Castellani JW, Montain SJ. Cognition during sustained operations: comparison of a laboratory simulation to field studies. Aviat Space Environ Med (2006; 77): 929-935.

distance from the center of the target and around 50% increase in sighting time. Also soldiers can still shoot close grouping at a fixed target, but if they are asked to shoot at a random pop up target at random locations, the performance drops to about 10% of the baseline[75]. The main conclusion is that sleep deprivation indeed affects accuracy and speed of shooting, but marksmanship on fixed targets remain stable due to muscle memory and a high level of previous training.[76]

US National Training Center Studies

Sleep related performance was also studied during a simulated mechanized infantry and armored battalion operation at the US California National Training Center. The 14-day operation consisted of a force-on-force and a live fire exercise. For the duration of the exercise, sleep was brief and fragmented. The study demonstrated an interesting correlation between rank, sleep performance and the headquarters level that the member was working in. The lower the rank, the higher amount of sleep was reported. Privates had 7-8 hours of sleep per night in comparison to the rank of LCol and Col who averaged around 4 hrs. The same can be said for the level of sleep by echelon: at the Crew and Squad level, sleep average 2-3 hours more than the brigade level. Figure 2.3 and 2.4 represents the tabulated result based on rank and echelon during the force-on-force, the live fire and while in the assembly area.[77] Sleep deprivation is thus greater the higher up the chain of command you go with the highest level of decision makers being

[75]Grey Belenky, The effects of sleep deprivation on performance…, 127-135.
[76] Harris R. Lieberman, Tharion William J., Shukitt Barbara, Speckman Karen L., Tulley Richard, "The Effects of caffeine, sleep loss, and stress on cognitive performance and mood during U.S. Navy SEAL training", *Psychopharmacology* (2002): 250-261.
[77] Grey Belenky, The effects of sleep deprivation on performance…, 127-135.

the most sleep deprived. Observation showed that the junior personnel were able to improve their performance during the exercise; however, the higher echelon was seen as "droning" and this was not improved.[78] This is an area that most armies need to address; officers need to be well rested in order to be able to better assess the situation on the ground and therefore make more rational decisions.

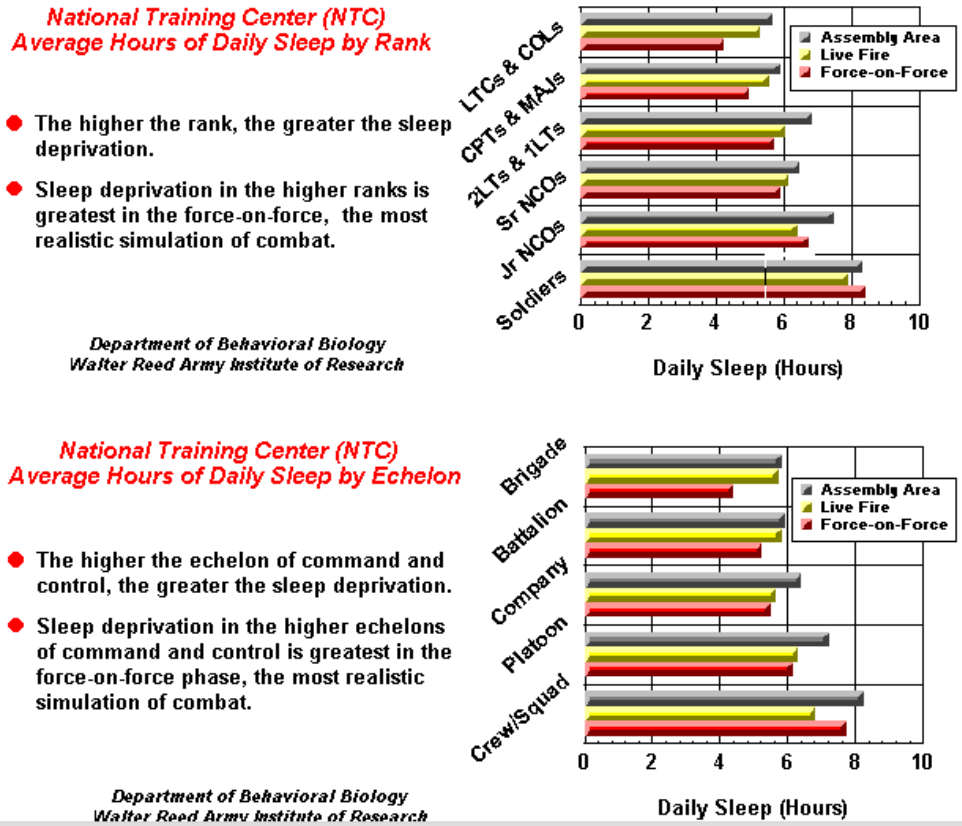

Figure 2.3 and 2.4 Correlation between rank and hg level. # 2 page 4.[79]

[78] Ibid, 127-135.
[79] 2 Gregory, COL Belenky, Sleep, Sleep Deprivation, and Human Performance…, 4.

Laboratory simulation of an Artillery Fire Direction center (US)

In 1981, Banderet and his colleagues from the United States Army Research Institute in Environmental Medicine (USARIEM) conducted a study of sustained operations in conjunction with the Artillery Fire Direction Center (FDC). Artillery teams were placed in a simulation of FDC operations such as unplanned targets, pre-planned targets and concurrent fire missions. The degradation of performance started to show after 24 hours, and by 48 hours all teams had elected to withdraw.[80] Through the simulation, the team's ability to derive range, bearing, elevation and charges remain accurate and was mostly unimpaired. However, as time passed, general planning activities (own situation awareness (SA), blue and red SA, computing of pre-planned targets mission following reception) deteriorated markedly. The situation map was no longer updated and targets missions became simply coordinates, as the soldiers no longer understood what they were firing at nor were they validating the targets. Their military skills were still effective as they were still firing on target, but neither cognitive function nor assessment was done after 24 hours.[81] Although not in the original scope of studies, team cohesion clearly made a difference in the team performance: teams with higher cohesion functioned better and cohesion was preserved longer during the simulation.[82]

To summarize this section, the US Army Ranger School Studies suggested that overcoming the effects of sleep deprivation can be learned and loss of sleep can be mitigated with long and intense training. The Navy Seal candidates study demonstrated that sleep deprivation will affects accuracy and speed of shooting, but marksmanship on

[80] Gregory L. Belenky, *Effects of Continuous Operations (CONOPS) on Soldier…,* 1-5.
[81] Grey Belenky, The effects of sleep deprivation on performance…, 131.
[82] Gregory L. Belenky, Effects of Continuous Operations (CONOPS) on Soldier…, 1-5.

fixed targets remains stable due to muscle memory. The correlation between rank and level of headquarters was demonstrated with the National Training Center studies; the higher the rank, the less sleep the soldier is getting and at a higher formation the lack of sleep is greater. Finally, the Artillery Fire Direction Center study demonstrated that after 24 hours sleep deprivation the learned military skills, like firing on target, were still effective, but cognitive functions were quickly degrading.

Physical effects of sleep deprivation

Sleep deprivation can also affect the soldiers' physical abilities. Keeping in mind the current Canadian Army policy stating that a soldier can be awake for 72 hours and still be able to accomplish physical tasks, the following section will review the literature, detailing the physical aspects of sleep deprivation.

The unique severe physical demands of military operations have been a prime platform for studying the effects of sleep deprivation and prolonged exercise. Studies have demonstrated that sleep deprivation alone does not significantly impair physical work ability. However, exercise compounded with sleep deprivation increases negative mood disturbance and reaction time. In a study on exercise abilities, Lucas (2008) concluded with the following statement that summarizes very well the literature on the subject: "in highly motivated and trained individuals, ultra-endurance exercise and sustained operations can be tolerated with minimal decrements in exercise and operational capacity, and that any physiological or psychological impairment resolve

relatively rapidly with appropriate recovery."[83] Vanhelder and Radomski came to a similar conclusion in a very extensive study: 72 hours' sleep deprivation does not affect reaction or muscle strength; however, the time to exhaustion decreases.[84]

To validate the statement, "Prolonged physical work without adequate rest and energy intake can compromise physical performance"[85], the US Army Research Institute of Environmental Medicine conducted a study by experimentally constructing a sustained physical exertion exercise under sleep deprivation conditions. Military volunteers were tested during a 92-hour sleep deprivation period, while performing regular military physical tasks like navigation, ruck marches and an obstacle course. The outcome is similar to the one above. During sustained operations, decrements in performance is in general restricted to tasks that recruit muscle groups that are over-utilized (trench digging), but for the other general military tasks (grenade throwing, soldier mobility), overall performances are maintained fairly well.[86]

Sustained and continuous performance studies

This section will look at a series of studies conducted in sustained operations ranging from 36 to 72 hours. The first study will look at the performance of infantry tasks during a 36 to 48-hour period of sleep deprivation. The second study will look at a 4-man crew conducting both offensive and defensive activities with sleep deprivation. The last

[83] Stephen Cheung, "Sleep and Exercise 1: Sleep Deprivation" in PezCyling News (19 may 2008): 1-5.
[84] June Pilcher, Effects of sleep deprivation on performance a meta-analysis, 318.
[85] Bradley C. Nindl and Al, "Physical performance responses during 72 h of military operational stress", Medicine Science Sport (Exercise 34 no 11, 2002), 1814.
[86] Ibid, 1821.

section will cover a series of studies conducted over 10 years with different resting periods for each sub-unit.

During a series of field studies by Banks and colleagues in a sustained operations context, ranging from 36 to 48 hours three major infantry tasks were observed: Surveillance-target acquisition (with and without night vision equipment), rifle firing, and grenade throwing. The results show a fairly stable performance with the soldier performance variable mostly attributable to fatigue, affecting the vigilance aspect of the tasks.[87] Banks also looked at a correlation with rotation of tasks between soldiers to see if there would be any change to the performance. He noted that the rotation did not enhance or decrease performance.

During a 48-hour sustained operations field study, Ainsworth and Bishop (1971) studied twenty - 4 man crews conducting both offensive and defensive activities, including communication, driving over challenging terrain, target surveillance, gunnery and associated maintenance.[88] Once again, there were no serious performance decrements: after 48 hours they slow down their overall performance, but were still fairly effective.[89]

With similar results Caille and colleagues (1972) reported that 64 to 72 hours of sleep deprivation does not severely impact the overall fighting efficiency of well-trained soldiers, as muscle memory and previous training compensate for the lack of sleep. They

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[87] Gerald Krueger, "Sustained work, fatigue, sleep loss and performance: A review of the issues", Work & Stress, (3:2, 1989): 129-141.
[88] Gregory L. Belenky, Effects of Continuous Operations (CONOPS) on Soldier…, 10-20.
[89] Gerald Krueger, "Sustained work, fatigue, sleep loss and performance: A review of the issues", *Work & Stress, (*3:2, 1989): 129-141.

also concluded that on most tasks, only decision-making and long-term memory showed signs of performance decrements.[90]

In a series of three studies conducted by Haslam and colleagues from 1977-1987, three different parachute platoons participated in a 9-day continuous infantry operations exercise. Each platoon was allowed a different amount of sleep: "A" platoon was not permitted any sleep," B" platoon was allowed 1.5 hours of sleep per 24-hour period and "C" was allowed 3 hours of sleep per day. During the experience, military performance was assessed, including shooting, weapon handling, digging, marching and patrolling. They also had to complete a daily cognitive test including map plotting, encoding and decoding, logical reasoning and short term memory. Here are the results: "A" was militarily ineffective after 72 hours of sleep deprivation and all soldiers had voluntarily withdrawn after 92 hours without sleep. "B" was militarily ineffective after 6 days (144 hours); however, 39% of the soldiers withdrew after 5 nights of sleep deprivation. "C" platoon, which was allowed 3 hours per night, remained effective until the end with none withdrawing.

Haslam and colleagues, using an different approach but the same testing methods, looked at soldier performance after 90 hours of non-stop military tasks followed by a 4-hour sleep per 24 hours period until the end of the 9th day. The study was done using two different test groups. All participants completed the trial and the main effect of the lack of sleep was psychological; mental ability and mood was deteriorated, but the most deterioration was observed in the vigilance tasks and during detailed cognitive tasks. The physical fitness remained fairly stable throughout. The 3 hours' sleep of the 4th and 5th

[90] Ibid,129-141.

nights was enough to restore the performance of the soldiers to almost 80% of the baseline.[91] Also, it was noted that after 3 days' of sleep deprivation, a 2-hour nap produced a great level of performance improvement and the effect of four 1-hour naps was nearly the same as a continuous 4-hour sleep period.[92] Therefore, during sustained operations, the key to success is having the right amount of sleep to remain effective. This study will serve as the basis for some recommendations discussed in chapter 4.1

To conclude, this section looked at a series of studies conducted in sustained operations. In the first study, Banks concluded that during a 36 to 48-hour sleep deprivation period soldiers showed a fairly stable performance with the soldiers' performance variable, mostly attributable to fatigue, affecting the vigilance aspect of the tasks. Ainsworth and Bishop in their 4-man crew study demonstrated that once again, there were no serious performance decrements: after 48 hours they slowed down their overall performance, but were still fairly effective. And finally, Haslam, in his series of studies, demonstrated that with 3 hours of sleep per night soldiers can remain effective for at least 10 days.

Sleep deprivation and its effect on decision-making

As briefly described in Chapter 1, sleep deprivation can and will cause impairment in decision-making. The following section will conduct a literature review of studies; both civilian and military, to assess the impact of sleep deprivation on decision-making. First, decision-making under sleep deprivation will be explained with the help of

[91] Gerald Krueger, *Sustained work, fatigue, sleep loss and performance*…, 135.
[92] Ibid, 135.

three different studies: cognitive task performance of military personnel over 48 hours sleep deprivation, followed by an Army Research Institute of Environmental Medicine study during a 92-hour period of sleep deprivation, and finally a study on radio traffic handling. The second topic will be sleep deprivation and moral reasoning with a study involving Norwegian cadets and a study involving the Iowa Gambling test. And finally, the following two questions will be answered: do soldiers know that they are tired or about to fall asleep? And is learning to cope with sleep deprivation even possible?

Decision-making under sleep deprivation

Understanding the cognitive consequence of lack of sleep is fundamental in an institution like the military where we rely heavily on soldiers to perform critical tasks while sleep deprived. With previous research having presented mixed results on the cognitive effects of sleep deprivation over decision-making, David Schnyer and colleagues conducted an intensity study to have a better understanding of the effect. In accordance with the existing literature, they conclude that after 24 hours of sleep deprivation, there is a minimal effect on simple decision-making but a clear vulnerability for integrated decision making.[93] In relation to our soldiers, they would still be able to perform simple decision tasks like plotting enemy positions on a map, but would not be able to conduct an analysis of where the enemy is coming from and where it is going. So the areas where the soldier requires flexibility, innovation and plan revision would be affected after 24 hours without sleep.

[93] David Schnyer, Zeithamova Dasa, Williams Victoria, "Decision-Making Under Conditions of sleep deprivation: Cognitive and Neutral Consequences", military Psychology, (Vol 21, 2009): 1-2.

An interesting study conducted by May and Kline in 1987 monitored the cognitive task performance of military personnel over a two-day sleep deprivation period. The result, like Schnyer, revealed that the soldier coped well with convergent tasks (where they can achieve the answer using a logical approach or detection) but not so well with innovative thinking tasks: they were struggling to generate spontaneous ideas.[94] In a combat situation, innovative thinking skills are essential for dealing with the very first nature of combat: a complex and unpredictable situation.

In 2006, the Army Research Institute of Environmental Medicine (US ARIME) conducted a study of cognition during sustained operations, using a laboratory simulation of a field's sustained operation to determine the change in cognitive function and mood after a prolonged sleep deprivation period. During the 92-hour study, 13 volunteers were conducting scenarios including road marches, battles drills and land navigation. They were only permitted two 1h rest periods each day; while not performing physical tasks, the participants were performing mental tasks to keep them awake. The study concluded that they experienced a significant decrement in reaction time and visual vigilance. Two areas remained relatively stable throughout the period: marksmanship and physical performance. This shows that cognitive function decreases significantly faster than physical performance. Also, the volunteers' mood significantly deteriorated over the course of the study.[95]

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[94] Yvonne Harrison, Horne James, "The impact of sleep deprivation on decision making: A review", *Journal of experimental Psychology: Applied* (Vol 6, No. 3, 2000): 238.

[95] H.R. Lieberman, Niro P, Tharion WJ, Nindl BC, Castellani JW, Montain SJ. Cognition during sustained operations: comparison of a laboratory simulation to field studies. Aviat Space Environ Med 2006; 77: 929–935.

In 1985, Augus and Heslegrave investigated the effect of 54 hours' sleep deprivation on information processing and handling of message traffic, to mimic the role of a military command post. After 18 hours, the reaction time, logical reasoning, encoding and decoding and vigilance started to decline; by 6 hours later at 24 hours, it dropped to 70% of baseline. Their performance remained stable at 70% for another 18 hours until it dropped to 40% of the baseline between 42 and 48 hours. The performance remained stable from 48 to 54 hours.[96] During the experience not only was a diminution of performance observed, but there was also a deterioration of mood and motivation as the experience progressed. The other interesting point is the 6 hours of decreased performance coincided with the low point of the circadian cycle.[97]

Sleep Deprivation and Moral Reasoning

In an attempt to look at the effects of partial sleep deprivation on moral reasoning and the formation of moral judgements and behavior, Olsen and colleagues had 71 Norwegian naval and army officer cadets judge 5 dilemmas in rested and partial sleep deprivation conditions. The dilemmas were conducted both in classrooms and during field exercises. Their results can be summed up as follows: "ability to conduct mature and principally oriented moral reasoning was severely impaired. The officers became substantially more rules-oriented in the sleep-deprived condition, while self-oriented moral reasoning did not change."[98] This can be extrapolated to our soldier on the

[96] Gerald Krueger, *Sustained work, fatigue, sleep loss and performance*…, 130.
[97] Gregory L. Belenky, Effects of Continuous Operations (CONOPS) on Soldier…, 10-40.
[98] Olsen O. Kjellevold, Pallesen S, Eid J. The impact of partial sleep deprivation on moral reasoning in military officers. Sleep. 2010; 1086–1090.

battlefield for whom lack of sleep can impact moral reasoning and this can affect the disproportionate use of force or power. This is why the use of SOP and Rules of Engagement (ROE) are essential, as they serve to simplify rules to enhance the decision-making process in a complex situation.

Now that the moral reasoning implication of sleep deprivation has been established, there is a need to look at the correlation between sleep deprivation and risky decisions. Unfortunately, very little exists on this topic in the literature for military-specific studies. One of the most conclusive studies was done in 2005 by William and colleagues from the Walter Reed Army Institute of Research. In a 49.5-hour sleep deprivation experiment, thirty-four participants completed the Iowa Gambling test[99] (this test is used to replicate real life decision making under uncertainty conditions) at baseline and at the end of the experimentation. At baseline the participants quickly learned to avoid the high risk deck of cards in favor of the most advantageous (in the long term) deck of cards. However, in the test at the end of the sleep deprivation period, their pattern of performance was strikingly different from the baseline: they tended to choose the risky deck of cards more often than not as the game progressed, demonstrating that risky decisions may increase with sleep deprivation.[100]

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[99] Participants are presented with 4 virtual decks of cards on a computer screen. They are told that each time they choose a card they will win some game money. Every so often, however, choosing a card causes them to lose some money. The goal of the game is to win as much money as possible. The decks differ from each other in the number of trials over which the losses are distributed. Thus, some decks are "bad decks", and other decks are "good decks", because some will lead to losses over the long run, and others will lead to gains.

[100] William Killgore, Balkin Thomas and Wesenten Nancy, "Impaired decision making following 49 h of sleep deprivation", *Journal of sleep research* (April 2006): 7-13.

Do soldiers know that they are tired or about to fall asleep?

Once of the effects of sleep deprivation is that it affects the ability of the person/soldier to assess their own degree of tiredness. Studies have demonstrated that soldiers don't necessarily know that they are tired. Itoi and colleagues in 1993 conducted a study in which participants were asked, using a percentage likelihood scale, to predict if they would fall asleep in the next 2 minutes. In the situation where the subject did fall asleep in the next two minutes, the average likelihood of correct prediction was only 55%.[101] This demonstrated that many of those who did fall asleep did not think that they would, showing their inability to assess their own tiredness.

This can have severe implications. In Flying Safety Magazine, a KC-135 air refuelling tanker pilot recalled a potential accident that could have happened in Iraq due to a lack of sleep, especially due to too many missions with very little sleep. During a short period of time he not only flew 12 six- to seven-hour missions, but also had to take part in all pre and post flying requirements. He recalled that his crew looked like "the walking dead." Capt. Drummond went on to explain that they were not aware of their level of tiredness, and he also added the following: "Even though I was getting enough rest at night, during the 11 straight sorties, my body and senses became very numb. I truly believe, because of the demand for the missions, our crew had become so tired that we forgot the little things, which can add up to big things."[102]

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[101] Chris Johnson, "The systemic Effects of Fatigue on Military Operation", *Department of computing Science, University of Glasgow*, (2012): 2.

[102] US Department of Defense Congressionally, Researcher Studies Sleep Deprivation's effect on decisions, 1-7.

Because you can have a soldier on a critical observation post falling asleep without knowing that he was that tired, measures must be put in place to mitigate this situation. Chapter 4 will cover mitigating factors in greater detail.

Can resilience to sleep deprivation be learned?

Can we teach our soldiers to be more resilient to sleep deprivation? Yes and no. Researchers have demonstrated that memory is marginally impacted by 24-hour sleep deprivation, due in part to the ability of our brain to compensate for lack of sleep in the first 24 hours. However, brain compensation is not forever; in all subjects after 60 hours no more compensation could be observed[103]. The brain can be trained to compensate for the first day or so, so with training our soldiers could become a little bit more resilient to the effects of memory loss due to sleep deprivation.

Dr Mario Jonavonic (2012) studied the impact on a specific shooting task of sleep deprivation conditions. The research was conducted using a sample of 19 members during the Croatian Special Operation Battalion training course. The main objective of the test was to assess the sleep deprivation factor during a specific task of shooting targets in four different ways with regards to body position in relation to the target.[104] His secondary finding is what is important for this paper. The result obtained suggested that during the training, adaptation to stress had occurred resulting in better shooting performance in

[103] US Department of Defense Congressionally, Researcher Studies Sleep Deprivation's effect on decisions, 1-6.
[104] 28 page 1Jovanovic Mario, "The effects of basic military training on shooting task in conditions of sleep deprivation", kinesiology 44(2012):1.

stressful and sleep-deprived situations.[105] This will be further discussed in Chap 4, when exploring ways to improve the soldier's performance during continuous operations.

But training under sleep deprivation conditions should not be done at every level. And some training/courses should optimise the amount of sleep the candidates are receiving by allowing a certain amount of sleep in accordance with the circadian cycle to maximize the leaning during the awake period. Studies of fatigue and training effectiveness in USN enlisted recruits were done to find the optimal sleep combination. After numerous trials, the pre-2001 standard of 6 hours of sleep per day for recruits was changed in December 2001 to 7 hrs between 9 p.m. and 4 a.m. In 2002 an additional change was made to 8 hours per night from 9 p.m. to 5 a.m. But once again, in mid-2002, a new change was made to reflect the circadian rhythms of adolescents and young adults (the majority of the candidates of a recruit course). The new sleep regime was 8 hours from 10 p.m. to 6 a.m. The studies demonstrated that that schedule was optimal for the learning and retention that those recruits have to do. While there is a time and a place to train our soldiers to withstand the effects of sleep deprivation, when acquiring new skills studies have demonstrated that 8 hours of sleep is recommended.

The main takeaways of this section are as follows. First with regards to decision-making under sleep deprivation, sleep deprivation has minimal effects on simple decision-making but a sleep deprivation effect will be visible after only 24 hours where the soldiers require flexibility and need to conduct plan revision. So in other words, soldiers will cope well with convergent tasks but not with innovative thinking tasks. Thus, compared to physical tasks, cognitive function decreases significantly faster. And

[105] Ibid, 1.

sleep deprived soldiers will be more averse to risk-taking, as demonstrated by the Iowa Gambling Test. Also, the short answer to whether soldiers are aware that they are tired or on the verge of falling asleep; is that unfortunately it is very difficult to predict if we will be falling asleep in the next minute. Therefore, a soldier can fall asleep at any time, regardless of his willpower. Fortunately, studies have demonstrated that there are mitigating factors that can help in training for sleep deprivation prior to departing on a mission.

Consequences of Sleep Loss/Restriction

As mentioned briefly in the first chapter, and from the literature review described above, numerous aspects of soldiers' behavior are affected by the lack of sleep. By discussing the following topics, tonus and posture maintenance, exteroceptive impairments, effectiveness and accuracy of cognitive and operant processes, vigilant attention and speech deterioration, this section will provide a summary of the consequences of the lack of sleep that soldiers can expect/face while being exposed to sleep deprivation.

Tonus and posture maintenance

How does sleep deprivation affect postural control? In 2008, a study investigating the impact of sleep deprivation on tonus was conducted using 18 healthy subjects. The subjects were tested first at baseline (without sleep deprivation) and following 24- and

36-hour sleep deprivation. They were tested using posturography[106] (with open and closed eyes) and vibratory proprioceptive stimulation. The results concluded that sleep deprivation over 24 hours results in a decrease of postural control; in other words, after a day without sleep our soldier will be more prone to falls, therefore more prone to be accidentally injured. An interesting point from the study to mention is that the effects on postural control barely change throughout the sleep deprivation period; it does not increase between 24 and 36 hours.[107]

Exteroceptive impairments

Sleep deprivation can have an effect on external senses. Research has demonstrated that sleep loss can result in inaccurate image formation on the retina, causing visuals errors, double vision and also hallucinations, as seen when the soldiers fire at real human targets during live range practice. Studies have also demonstrated that sleep loss can cause hyperesthesia or limb numbness and an increased sensitivity to pain. Likely, auditory errors and sense of temperature does not increase significantly after sleep deprivation.[108]

Effectiveness and accuracy of cognitive and operant processes

[106] Posturography is a general term that covers all the techniques used to quantify postural control in upright stance in either static or dynamic conditions (wiki)
[107] Patel M, Gomez S, Berg S, Almbladh P, Lindblad J, Petersen H, et al. "Effects of 24-h and 36-h sleep deprivation on human postural control and adaptation.", Experimental Brain Research (2008;185): 165–73.
[108] Jolanta Orzel-Gryglewska, Consequence of Sleep Deprivation, 100.

The studies have demonstrated that sleep loss impairs the concentration of attention with increased episodes and duration of micro sleeps and mental thoughts are somewhat distracted. Those effects have a direct negative impact on the accuracy and effectiveness of the soldiers' work performance and his or her cognitive processing. As seen in previous studies, 24 hours' sleep deprivation decreases the cognitive response by approximatively 25%. A decrease in cognitive performance will be observed with less than 7 hours of sleep in each 24-hour period. If a soldier receives between 4 and 7 hours of sleep every 24 hours, cognitive performance will stabilize at a lower level. With under 4 hours of sleep it will continuously degrade with no stabilisation[109]. Under sleep deprivation we can expect our soldiers to be less effective in innovative thinking and decision-making while the possibility of risk for risky decision-making may also increase. Thus a military leader in severe sleep deprivation could make questionable decisions that can cost the lives of numerous soldiers.

When soldiers are very tired, muscle memory takes over, and they will still hit the target but their judgement and the ability to properly process the information around them to positively identify the target will be lacking. This could have catastrophic consequences. One study demonstrated very well the combination of those impacts on real life operations. The study was done by looking at the reactions of soldiers under stressful and sleep-deprived conditions. During a live firing exercise, those soldiers were asked to fire at the targets ahead of them. The "usual" paper targets had been replaced by real people. The result was shocking: the majority did fire their weapons, and only one

[109] Tom M. McLellan, Doug G. Bell, Harris R. Lieberman, and Gary H. Kamimori. "The impact of caffeine on cognitive and physical performance and marksmanship during sustained operations.", *Canadian Military Journal* (Winter 2003-2004): 1.

soldier warned his colleagues that they were real humans and not paper targets.[110] The soldiers had lost the ability to do proper target discrimination.

Vigilant Attention

"Sleep deprivation severely compromise the ability of human beings to respond to stimuli in a timely fashion."[111] This is partly due to a decrease in vigilant attention. In a series of complex studies and literature reviews, Lin and Dinges used the psychomotor vigilant test (PVT) to find a correlation between vigilant attention and lack of sleep. There are four main findings that have been largely accepted by the scientific community. First, sleep deprivation will result in a decrease of vigilant attention. Second, the propensity of a soldier to lapse for lengthy periods will increase with the amount of sleep deprivation. Third, time on task effects will increase with the lack of sleep, and finally the PVT result shows the same oscillation curve as the circadian cycle.

Reduced odor perception

Soldiers under sleep deprivation conditions will also show signs of reduced odor perception. Studies using the smell identification test have demonstrated that sleep-deprived individuals, compared to their baseline performance, show a significant decline in the ability to recognize and successfully identify specific odors. The impact, however,

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[110] Chris Johnson, *The systemic Effects of Fatigue on Military Operation*, 3.
[111] Julian Lim, Sleep Deprivation and Vigilant Attention, 1.

on the odor perception during a combat mission is very low and will have very minimal, if any consequences.

Speech deterioration with Air Force example

Speech performance is also affected by prolonged wakefulness. A sleep-deprived soldier has difficulty properly expressing and verbalizing their thoughts and concepts, speaking monotonously and having a tendency to use word repetition and clichés[112]. This can have significant impact for the leadership passing on verbal orders to their soldiers. A study of radio communication between crews showed changes to vocal parameters like reduced intonation and speech slowing. Other decrements observed were the impairment to the retrieval of words and the qualities of the choice of words decreased with the lack of sleep[113].

Conclusion

The literature of sleep deprivation provides numerous studies to demonstrate the impact of sleep deprivation on our military forces. The lack of sleep or sleep loss is the leading factor in the soldier's performance degradation. As discussed, sleep loss can and will have a severe impact on the overall mission. The following tables are an overview of the effects of sleep loss on soldiers, as well as, the indicators of sleep deprivation and fatigue that should be well understood by the chain of command and the soldiers themselves.

[112] Jolanta Orzel-Gryglewska, Consequence of Sleep Deprivation, 100.
[113] Yvonne Harrison, The impact of sleep deprivation on decision making, 241.

AFTER 24 HOURS	A deterioration in performance of tasks that are inadequately or newly learned, that are monotonous, or that require vigilance.
AFTER 36 HOURS	A marked deterioration in ability to register and understand information.
AFTER 72 HOURS	Performance on most tasks will be about 50 percent of normal.
3 TO 4 DAYS	This is the limit for intensive work including mental and physical elements. Visual illusions are likely at this stage, or earlier, especially in NBC.
BETWEEN 0300 & 0600 HOURS	Performance is at its lowest ebb.

Figure 2.5 Effects of sleep loss[114]

PHYSICAL CHANGES	Body swaying when standing. Vacant stares. Pale skin. Slurred speech. Bloodshot eyes.
MOOD CHANGES	Less energetic, alert, and cheerful. Loss of interest in surroundings. Possible depressed mood or apathetic and more irritable.
EARLY MORNING DOLDRUMS	Requires more effort to do a task in the morning than in the afternoon, especially between 0300 and 0600.
COMMUNICATION PROBLEMS	Unable to carry on a conversation. Forgetfulness. Difficulty in speaking clearly.
DIFFICULTY IN PROCESSING INFORMATION	Slow comprehension and perception. Difficulty in accessing simple situations. Requiring longer to understand information.
IMPAIRED ATTENTION SPAN	Decreased vigilance. Failure to complete routines. Reduced attention span. Short-term memory loss. Inability to concentrate.

Figure 2.6 Indicators of sleep deprivation and fatigue[115]

[114] US Department of Defense, FM 3-21.31 Appendix A Continuous Operation, 4.
[115] Ibid, 4.

This chapter focused on laboratory and field studies, but unfortunately we also have some "after the fact" data from accidents/incidents that happened in real theaters of war due to lack of sleep. There are many incidents in civil aviation that have been linked to sleep deprivation and these are well documented; therefore, the next section will focus on a land accident due to sleep deprivation. Dr. Bentley conducted an after-action debriefing with the soldiers involved in a friendly-fire incident in the 100-h ground war during Operation Desert Storm. After more than 48 hours of sleep deprivation, a platoon of six Bradley fighting vehicles was told to stop advancing and to set-up a screen line. On each flank of the platoon was another Bradley platoon. After a fire fight with the Iraqis, it was assessed that two Bradleys had been destroyed (luckily no casualties). The after-action report demonstrated that they were destroyed due to friendly fire. Due to sleep deprivation, the soldiers lost track of where the front was and engaged their flank, as they thought it was the enemy[116]. This is a clear example of why sleep deprivation management needs to be taken very seriously, as it can save lives.

The previously discussed studies all suggested or it can be extrapolated to validate the following statement. In a high tempo military operation, complex mental operations such as orientation with friendly and enemy forces, coordination and information processing, force preservation and regrouping and finally command and control activity will all be affected to a certain degree by the lack of sleep of our soldiers. Yet the current BGL state that that soldiers are expected to remain effective for up to three days—72 hours—without sleep. This chapter clearly demonstrates that the BGL is not realistic and it needs to be re-written to reflect the result of over a century of intense research.

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[116] Grey Belenky, The effects of sleep deprivation on performance…, 131.

The studies discussed in this chapter clearly support the argument that fatigue should be viewed as a systemic problem during military operations. As demonstrated earlier, incidents and accidents will only increase if we continue to rely solely upon individuals to assess if they need a break or if they are still efficient despite the lack of sleep. Therefore, the next chapter will focus on how the armed forces of some of Canada's allied countries cope with sleep management during continuous operations.

CHAPTER 3: SLEEP MANAGEMENT POLICY

Introduction

To be perform efficiently, our soldiers need to be well rested, and as seen earlier, sleep is crucial for the mental reasoning needed to make life and death decisions. But how can we expect our soldiers to be rested in an operational environment where the sleeping conditions are less than optimal and soldiers are required to conduct operations around the clock. As explained earlier, the average amount of sleep required by an individual is between 7 and 8 hours a night, and with less than 4 hours' sleep, performance will be degraded. Those who are familiar with the tempo of our modern soldiers in theaters of operations understand that sleep management is a tremendous challenge and it would be very difficult to give each and every one of our soldiers the proper rest time in accordance with the circadian cycle. This chapter will provide guidance and review other nations' sleep management policies in order to provide all the necessary background to recommend a new Canadian Army policy with regards to sleep management to replace the current BGL, which only provides very limited and outdated information. But first the current Canadian Policy will be reviewed and discussed.

Current Canadian Sleep Management Policy

The only document in the Canadian Army (not including the other services, which have policies on crew rest and shift work) that discusses the effects of sleep deprivation is the B-GL-334-001/FP-001 Standing Operating Procedures (SOP) for land Operations. This document is very well known by most soldiers and all officers on the common Army

Phase (CAP) receive a copy of the tactical aide-memoire (TAM) included within the BGL. The section on sleep deprivation is actually located within the TAM in table 503.04, titled Effects of Sleep Loss.[117] The table is located below and covers very little information. It provides very basic expectations for behavior after 24/48/72 hours and 3-4 days of sleep deprivation. It also addresses the impact on the circadian cycle, stating that performance will be the lowest between 0300-0600. Finally, the table provides some of the impacts and effects of sleep deprivation. The guide provides good information but no context is given, leaving much room for wrongful interpretation. For example, the table states that 3-4 days without sleep "is the limit for work, including mental and physical aspects," giving the reader the understanding that up to that point a soldier can still accomplish any task. Chapter 2 identifies that mental tasks would be very unlikely after 48-72 hours.[118] The two key ideas for the review of the Canadian policy is that some substance is needed to properly identify the effects of sleep deprivation and that there is a danger with giving a maximal/minimal amount of sleep required.

[117] Department of National Defence, B-GL-334-001/FP-001 Standing Operating, TAM 503-3.
[118] Ibid, TAM 503-3.

Time frame:	
After 24 hrs	There will be a deterioration in performance in tasks that are newly learned, or monotonous, or that reqr vigilance.
After 36 hrs	There will be a marked deterioration in ability to register and understand info.
After 72 hrs	Performance of most tasks will be very poor. Pers most affected will be those doing continuous mental work. All tasks are likely to take longer.
3 to 4 days	Without sleep is the limit for work, incl mental and physical aspects. Visual illusions are likely at this stage, or earlier, especially in dress category MOPP HIGH.
Tasks Effected:	
At 0300 to 0600 hrs	Performance at its lowest ebb, especially after sleep loss.
Most affected tasks	Complex, uninteresting, requiring sustained attention, surv and comd functions.
Least affected	Short, simple, self-paced, well-learned, interesting.

High workloads	More than low ones due to increasing lapses in attention.
Routine tasks	Routine but critical subsidiary tasks tend to be skipped, a gen unwillingness to act or respond.
Insight	Reduced, performance and abilities are overestimated.
Initiative	Ability to initiate work decreases.
Memory	Short-term memory is impaired.
Need for naps	For all rks the importance of even short naps (1 hr) should be recognized.
Effects:	
Main effects on mental processes:	Tasks most adversely affected:
Lack of concentration Reduced vigilance Slowing of action Impaired memory Misinterpretation Visual illusions Disorientation	Sustained Unstimulating Work-paced Surveillance Inadequately-learned High workload Complex decision-making

Table 3.2 TAM 503.04

Furthermore, the document does not provide any mitigating factors or sleep management techniques. As demonstrated in chapter 2, soldiers could remain combat effective up to 10 days if they get 3 hours of sleep per 24 hours. This information is vital in the planning of a sustained mission, but unfortunately, the responsibilities of the chain of command are not mentioned. So the table provides very basic information with

minimal context and does not provide any planning guidance. In fact, it talks about sleep deprivation as a problem with no solution and an inevitable prolonged combat problem. The rest of the chapter will look at sleeping considerations in operational environments and sleep management followed by a review of other nations' guidelines with a view to compare our current guidelines and develop our new and improve directive.

Sleeping in the operational environment

Experts recommend sleeping in a dark room in a stress-free area where the noise is minimal and ambient temperature is at an ideal level.[119] Soldiers deployed overseas are faced with many challenges with regards to sleep. First, soldiers usually share very basic accommodations that provide very little in terms of comfort with regards to noise, heat or cold, and light. Second our soldiers can be awake at any hour of the day or night in case of an enemy attack, where stress factors will always be present. Those challenges are unique to our military forces and require unique strategies to overcome and maximise the rest time of our soldiers. Therefore, the militaries around the world need to develop sleep management programs to increase the efficiency and well-being of their soldiers.

Most military operations have one thing in common, they often result in sleep deprivation. Even short duration operations may result in sleep deprivation, as the soldiers may arrive in a state of jet lag and may be required to immediately conduct sustained short duration operations. The US military uses two terms to discuss those situations: Continuous Work Episodes (CWEs) and Sustained Operations (SUSOPs) or Continuous

[119] Appendix B: Sleep Management, Sleep Deprivation, *Walter Reed Army Institute of Research (2007):*215-216.

Operations (CONOPS). In general, SUSOPs contain one or more CWEs and last at least 24 hours.[120] Prior to the improvement in technology, the ability to operate at night and unreliable equipment were factors in the CWEs' time limitation, but today the only limiting factor is endurance: a function of sleep. As stated in the US Army manual, "During continuous operations, leaders and soldiers must think faster, make decisions more rapidly and act more quickly than the enemy."[121] In chapter 2, numerous research studies were reviewed to determine the impact of sleep deprivation on our soldiers, and most of those effects will be seen at a various degrees in soldiers during Sustained Operations. Hence, the chain of command needs to follow sleep management protocol.

The current Canadian Guideline is not a sleep management protocol and does not provide the chain of command with direction and/or information about sleep management or how the mission would really be affected by the soldiers' lack of sleep.

Sleep Management and Sleep Logistics

What is sleep management? Dr. Naitoh from the US Naval Health Research Center provides the following definition. "Sleep management is the study of sleep, its effects on personnel, and methods to satisfy sleep requirements under demanding work schedules."[122] Some of our allies, including the US and Australia also utilize the term sleep logistics in conjunction with sleep management. Indeed, they recognize that sleep

[120] G. C. K. Giam, Effects of Sleep Deprivation…, 90.
[121] US Department of Defense, FM 3-21.31 Appendix A Continuous Operation, 1.
[122] P. Naitoh, Sleep Management User's Guide for Special Operations Personnel, 3.

logistics is the application of sleep management to military operations[123] to ensure that soldiers at all levels obtain sufficient sleep to remain combat effective.

Sleep management and sleep logistics are intended to assist the chain of command and the soldiers themselves to prevent compromise of the mission due to sleep deprivation. Sleep management uses scientific techniques and lessons learned from previous studies to optimize sleep for those soldiers who have to work under demanding shift work schedules or soldiers involved in CWEs.[124] The main purpose of sleep management is "the prevention of and compensation for deteriorating performance, mood and motivation caused by lack of sleep."[125]

There are two steps common to most sleep management protocols; the first is to develop a work/sleep plan to meet the soldiers' sleep needs while balancing the needs of the mission, and the second is to employ self-diagnostic techniques to overcome and detect the negative effects of sleep deprivation. The current Canadian guideline are clearly lacking both steps, thus in development of the new Canadian sleep management plan in chapter 4, those two steps will be taken into consideration. The next section will focus on how the Americans and the Australians conduct their sleep management and sleep logistics in sustained military operations.

Australian Army Sleep Management Policy

[123] P. Naitoh, Sleep Management User's Guide for Special Operations Personnel, 3.
[124] G. C. K. Giam, Effects of Sleep Deprivation…, 90.
[125] Ibid, 90.

The Australian Army is often used in comparison with the Canadian Army due to its similarity in terms of size, resources and budget. For this reason, the Australian army is the first choice for a sleep management program review in order to the develops a Canadian sleep management policy. In 2002, the Australian Defence Force Psychology Organisation and the Defence Science and Technology Organisation published a very interesting and complete guide on sleep deprivation with recommendations, titled, "Fatigue Management During Operations: A Commander's Guide."[126] The guide is around 90 pages long and covers an array of subjects related to sleep deprivation and prevention measures. The intent of the guide is to teach the soldiers basic information about sleep, discuss the causes and signs of fatigue and identify some of the effects of fatigue on performance, as well as, suggest methods of fatigue prevention. In addition, a whole chapter is dedicated to fatigue management as a leadership issue. The guide concludes with a chapter on fatigue management with guidance to the chain of command and soldiers. The next section will discuss the two key recommendations from the Australian Sleep Management Program: the Operational Sleep Requirement and the Fatigue Indicator.

Operational Sleep Requirement

The Australian Army provides a guideline for the minimal amount of sleep needed in operations. They divide their guidance into two categories: one for soldiers performing mental tasks and the other for soldiers involved mainly in physical tasks. The table not only provides the minimal sleep requirement, but also suggests a recovery period. The

[126] Australian Defence Force, Fatigue Management During Operation..., 1.

guideline can be seen in Table 3.1. The Australian Army, like the Canadian Army, also states that soldiers can accomplish physical tasks for up to 72 hours without sleep. They also caution the reader though, that every soldier is different and sleep requirements vary between soldiers. Some soldiers may require more or less than the guidelines; hence the chain of command and soldiers should be aware of fatigue indicators.[127] On a side note, the British forces also use the minimum operational sleep requirement table (Table 3.1) as part of their sleep management program.

Mainly Physical Tasks			***Mainly Mental Tasks***		
Acceptable performance (days)	Sleep required (uninterrupted)	Suggested recovery period	Acceptable performance (days)	Sleep required (uninterrupted)	Suggested recovery period
3	0	24 hrs	1	0	8-12 hrs
6	1.5 hrs per day	2 days	2	1.5 hrs per day	12-24 hrs
9	3 hrs per day	3 days	3	3 hrs per day	24 hrs

Table 3.1 Minimum Operational Sleep Requirements.[128]

Fatigue Indicators

To complement the sleep requirement guideline, the Australian Army has produced a fatigue checklist that comprises 12 questions of easily observable behavior that may be an indicator of the level of fatigue of the soldier. At the end of the checklist, three options are proposed: no immediate action required (i.e. soldier is not yet sleep

[127] Ibid, 69.
[128] Ibid. 69.

deprived), nap required, and finally, extended sleep required.[129] The intent is to have the leadership and/or the soldier use the checklist when they are unsure as to whether they are sleep deprived or not. This is also a tool for the commander to assess the overall effectiveness of his or her unit.

Overall, the Australian sleep management policy is a well-written and very instructive manual, but not very soldier-friendly, as is comprised of over 90 pages and the information is scattered in various chapters. It also places the emphasis on the chain of command's responsibility to implement a defined work/rest cycle in operations. One of the main concepts in the Australian document, the table of sleep requirement, is not being addressed clearly in the TAM; as it provides an overview of the effects after a defined timeframe, but does not provide any guidelines. If a table is to be used in the new Canadian version, based on the literature review conducted in chapter 2, the hours of sleep requirement should be adjusted to better reflect the scientific data available, i.e. the optimal minimal amount of sleep during infantry task missions should be 3 hours per 24 hours regardless of physical or mental work. Also, there is no fatigue checklist in the TAM; its addition should be taken into consideration in the development of the Canadian version.

American Sleep Management Policy

The United States Armed Forces is the world leader with regards to study in the field of sleep deprivation. It has numerous institutions with dedicated teams (Naval

[129] Ibid, 83.

Health Research Center and the Army Research Institute in Environmental Medicine, to only name a few) continuously studying sleep deprivation and working on the elaboration of counter-measures including both pharmacological and non-pharmacological interventions. Obviously the size and budget of the US Forces allows it to conduct extensive research and fortunately for the US allied forces, the US has been sharing the results of most of those research studies. As a result of this, the Canadian sleep management model will directly benefit from the US sleep logistic policy. The following section will review some of the key concepts from the three different sleep management policies: Performance Maintenance during Continuous Flight Operations, Sleep Management in Sustained Operations User's Guide[130],[131] and the sleep management appendix.[132]

Performance Maintenance during Continuous Flight Operation

The Performance Maintenance during Continuous Flight Operation manual is a guide for flight surgeons published by the Naval Strike and Air Warfare Center in 2000. Although the guide is over 15 years old, most of the information is still accurate and of interest for the development of the Canadian Guide. As the title states, this document focuses on air operations, because "fatigue in sustained, continuous naval flight operation is expected and can lead to poor flight performance and increased aircraft mishap

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[130] P. Naitoh, Englund C.E., Ryman, D.H, "Sleep Management in sustained operations User's Guide". Naval Health Research Center, Report no.86-22 (1986), 1-25.
[131] U.S. Naval Strike and Air Warfare Center, "Performance Maintenance during continuous Flight Operations- NAVMED P-6410", January 2000.
[132] Appendix B: Sleep Management, Sleep Deprivation, Walter Reed Army Institute of Research (2007): 214-219.

performance"[133]. Thus, preventing fatigue and maintaining optimal performance during sustained operations is fundamental and should be a primary concern of the chain of command. The author acknowledges that crew rest for flying operations is very different from the minimal amount of sleep required for a soldier to perform well, but the principles and ideas described in this manual can be extrapolated to reflect the need for sleep of a soldier during operations. This manual is about 21 pages long, using very simple terms easily understood by all airmen and airwomen. Also, for convenience, the manual comes with a PowerPoint presentation to allow the chain of command to pass the information to all stakeholders.

The manual starts by describing circadian rhythms and giving basic information about sleep. It also covers extensively the effect of anti-fatigue medications on the aircrew. The important topics covered in this manual include strategies and ideas at different levels of command (Wing, Squadron, and Individual) to overcome and manage the effects of fatigue. The approach used in the document is that every level of command shares a responsibility for fatigue management and it proposes that only a collaborative approach will improve the fatigue awareness and help to prevent catastrophic mishaps due to fatigue. Another interesting fact about this manual is that it does not mention a specific amount of time for crew rest and or sleep recovery; instead it provides strategies and ideas. The manual also provides real life examples using Desert Storm when fatigue and sleep deprivation were the cause of accidents and incidents, demonstrating to the readers how the strategies and ideas for sleep management could have prevented some of those accidents/incidents.

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[133] U.S. Naval Strike a, Performance Maintenance during continuous Flight Operations…,1.

Three main ideas can be drawn from the US Navy manual for the Canadian guide development. First simplicity in the manual is key for all soldiers to be able to develop a good understanding of the issues. The second is that having a set figure for sleep requirement is not necessarily the best focus for sleep management, but rather providing strategies and ideas is very practical. And finally, fatigue management is a responsibility at all levels of command, including the individual.

Sleep Management in Sustained Operations User's Guide

The Sleep Management in Sustained Operations User's Guide is a guide that has been developed by the Naval Medical Research and Development Command. The first version was published in 1986. Since then, there have been several versions of the document published for different services, including a very detailed guide on sleep management for the special forces.[134] All those guides have a very similar structure and the information content in all documents is very similar, with the exception that some of the examples presented are more service related. Therefore, the Army Sleep Management in Sustained Operations User's Guide[135] will be reviewed and analysed for the development of the Canadian guide.

The guide is a fairly detailed document of 25 pages covering the challenges of sleep deprivation, including background and problems. The second section describes sleep management. The third section is really the focus of the guide, identifying signs of performance degradation and providing information on preventing and overcoming

[134] P. Naitoh, Sleep Management User's Guide for Special Operations Personnel, 1-45.
[135] P. Naitoh, Sleep Management in sustained operations User's Guide, 1-45.

degradation. This section divides sleep management according to the five deployment phases: pre-deployment, deployment, pre-combat, combat and post combat phase, giving detailed explanations on some aspects of sleep management during each phase. This approach creates very easily understood prevention measures for the chain of command at those stages; however, the section doesn't address sleep management as a chain of command responsibility.

The guide concludes with six different techniques to overcome sleep deprivation during field training: the work/rest sleep plan, the recognition of sleep degradation, individual tolerance to sleep loss, self-control to sleep when the individual needs it, aids available to measure sleep loss effects and important facts about sleep.[136] Once again, the guide refrains from giving specific amounts of sleep time needed during specific situations (physical or mental tasks) as it states that each individual is different and the intent of the guide is to help the soldier to understand and overcome sleep deprivation on his or her own. The guide also lacks information about medication/drugs that could be used to overcome sleep deprivation. The guide does provide a list of good "field" sleeping techniques that can improve the soldier's sleep in the field. Overall the guide is useful for the individual, but for the chain of command it is not complete.

The key takeaway, missing from the current Canadian guide, from the numerous guides on sleep deprivation provided by the Naval Health Research Center is the phase approach of sleep deprivation using the doctrinal phases of operation and the individual techniques proposed to self-manage sleep deprivation, like the rest/work cycle plan, self-

[136] 27 Ibid, 1-45.

diagnostic techniques and good sleep skills to achieve the individual quantum of sleep needed.

Sleep Management Guidance by Walter Reed Army Institute of Research.[137]

The publication, Sleep Management Guidance, by the Walter Reed Army Institute of Research is one of the best documents on sleep deprivation management used by the US Army. Published as an appendix in the institute journal, the guide is supported by extensive research conducted at the institute and within other facilities in the United States. The guide is based on the most current research and was last modified in 2007. The guide is intended to be used to develop units' sleep plans; having been specifically written for the chain of command and comprises strategies to prevent sleep deprivation. It is a fairly short document, focused on basic facts, without referring to any of the extensive research conducted supporting its conclusions.[138]

The guide starts by offering the reader some basic information about sleep and sleep debt, and provides a guideline of 7 to 8 hours of quality sleep every 24 hours to sustain operational readiness. The second section focuses on sleeping in the operational environment and once again reiterates that less than 7-8 hours sleep will result in a decline in performance. It also provides a very detailed table on basic sleep scheduling factors and the need to obtain that critical amount of sleep. The factor discussed are timing of sleep period, duration of sleep period, napping, and prioritizing sleep need by task and individual differences. This section provides lots of consideration for the chain

[137] Appendix B: Sleep Management, Sleep Deprivation, *Walter Reed Army Institute of Research (2007): 214-219.*
[138] Ibid, 1-45.

of command to plan the work/rest cycle, one of the key elements of the sleep management plan. In addition to planning the right amount of sleep, there is also a need to plan for an optimal sleep environment considering noise, light, temperature and stimulants. Once again the guide provides mitigating methods to limit the environmental effects on the soldiers' sleep.[139]

The next section discusses the impact of caffeine on sleep. This section is important, as more and more soldiers are using caffeine products like coffee or energy drinks equivalents to stay awake without realizing that these may impact sleep quality. The last section focuses on specific sleep loss effects and how combat operation will be affected by the lack of sleep of the soldiers.[140]

Overall, this guide is a great tool for the chain of command to understand how they can reduce their soldiers' sleep deprivation. In the author's opinion, too much emphasis is placed on ensuring that every soldier receives at least 7-8 hours of sleep per night. As stated in chapter two, soldiers in a theater of operation rarely have more than a few hours of sleep per 24-hour period, making those recommendations a little bit unrealistic during operation. Thus, two key contributions of Sleep Management Guidance by Walter Reed Army Institute of Research that are currently lacking in the TAM, are the very good descriptions of basic sleep scheduling factors and effects as well as the important observation of caffeine's impact on sleep deprivation.

Conclusion

[139] Ibid, 1-45.
[140] Ibid, 1-45.

As seen earlier, "Sleep management is the study of sleep, its effects on personnel, and methods to satisfy sleep requirements under demanding work schedules.[141]" Each nation/service has its own sleep management policy and manual, and all are very different and aim at different levels, either the individual or the chain of command. But all of them contain basic information on sleep, sleep deprivation and techniques to overcome a state of sleep deprivation where the soldier is no longer optimally performing. Some nations provide a ratio of sleep/work time, like Australia and the UK, and some, like the US, provide only management methods. Our current BGL on sleep management is only a table providing very minimal information including a maximal amount a sleep deprivation a soldier can sustain (i.e. 3 to 4 days).

The review of those documents provides two common steps for a sleep management guide: first develop a work/sleep plan to meet the soldiers' sleep needs, and second, employ self-diagnostic techniques to detect the negative effects of sleep deprivation. Our four allies' documents and the Canadian TAM provide a list of important considerations for the development of the new and improved Canadian Army Sleep deprivation guide.

- The table of sleep requirements needs to include both physical and mental task requirements, but there is a danger with giving a maximal/minimal amount of sleep required.
- The need for a fatigue checklist to determine the state of sleep deprivation of a soldier.

[141] P. Naitoh, Sleep Management User's Guide for Special Operations Personnel, 3.

- Simplicity in the manual is key to ensuring better understanding by all soldiers; however, explanations are needed to properly identify the effects of sleep deprivation.
- Having a set figure for sleep requirement is not always the best focus of sleep management but rather strategies and ideas to cope with situations as they arise is preferred.
- Fatigue management is a responsibility of all levels of command, including the individual.
- It is important to use a phased approach for sleep deprivation using the doctrinal phases of operations.
- It is best to use an individual approach to self-managed sleep deprivation, like the rest/work cycle plan, self-diagnostic techniques and good sleep skills to achieve the individual quantum of sleep.
- Caffeine's impact on sleep deprivation must be addressed.

CHAPTER 4: LIMITATIONS & RECOMMENDATIONS

The right amount of sleep is essential to remain effective, and understanding the sleep domain is key to a successful operation. Long gone are the days in which combat operations could slow down at night. Today the enemy, like us, has the ability to conduct activities around the clock. The onus is now on who's able to cope better with sleep deprivation to remain combat effective. Therefore, three main topics have been reviewed in order to develop a well-researched and comprehensive guide for the Canadian Army.

First an overview of the science of sleep was done, with the main conclusion being that sleep varies between individuals—with an optimal amount of sleep being 7-8 hours per 24-hour cycle. Not only is the amount of sleep needed important, the timing of the sleep during a 24-hour day is also important. In fact, to be optimal, sleep should follow the individual circadian cycle. For most human beings, this means that optimal sleep should happen between midnight and 6 in the morning.

The second chapter focused on an up-to-date literature review of the most important and relevant sleep studies conducted since the 1960s. Hundreds of studies conducted both in military and civilian settings have provided widely accepted sleep deprivation effects, like cognitive function degradation of 25 % per day of sleep deprivation however, physical fitness remains stable over short periods of sleep deprivation (24-72 hrs).

As seen in the previous chapter, sleep management is the study of sleep, and most sleep management programs follow a two-step approach: a work and rest plan and employment of a self-diagnostic technique. The main means of preventing sleep

deprivation is to always provide our soldiers with a sufficient amount of sleep to maintain combat effectiveness. Also, the previous chapter looked at the Australian, American and our own Canadian sleep management policies and/or doctrines to establish the foundation for the creation of a new Canadian policy/guideline. The main points were that sleep deprivation should be looked at as a problem at all levels of the Chain of Comment including the individual, and second, the ability to develop a work/sleep plan is essential in combating the nesting effect of sleep deprivation on the overall combat effectiveness of a unit. Taking all the previous information into consideration, this chapter will focus on recommendations with regards to avoiding sleep deprivation in the Canadian Army.

Sleep Management: A Leadership Responsibility

The Navy and the Air Force both have clear guidance and directives on the amount of sleep each sailor and airperson shall receive, and the right application of that guidance will prevent sleep deprivation in those members. The reality of military operations on the ground precludes most of those techniques (i.e., crew rest and shift work) being used by the Army. Nonetheless, our soldiers still need to receive a decent amount of sleep to remain combat effective. In an operational context, the application of a rigid guideline of hours of sleep per 24 hours is nearly impossible; thus, the leadership must use their knowledge and common sense to mitigate the potential effects of sleep deprivation on soldiers during a mission.

As demonstrated earlier, the longer the soldiers are without sleep, the worse they will perform, and obviously this will have a direct impact on the overall effectiveness of

the mission. As stated in chapter 2 (during the Ranger course), during a long period of sleep deprivation, soldiers will eventually adapt to the lack of sleep and be able to survive on 3-4 hours' sleep per day, but they will experience numerous "droning" periods during the course of the day. Leaders must be aware of the cost of promoting minimal sleep in their unit and the danger of having soldiers "droning." When our soldiers are droning, they are not alert and therefore may not be in a position to complete the mission, or worse, to stay alive. When leaders understand the impacts of sleepy soldiers on the mission, they will be more aware of the importance of sleep. As a result, it is the responsibility of each level of the chain of command to optimize soldier effectiveness by providing them with the right amount of daily sleep. Or, they must be able to report to higher command levels that their unit will have difficulty achieving the mission due to lack of sleep. The latter part might be very difficult for a leader to admit, but as stated earlier, the need for sleep is not a weakness but a physiological need. As has been stated, one should "live to fight another day," but without proper management, this won't happen and the battle will be lost.

Not only do our soldiers need sleep, and officers at all levels should use their sleep knowledge and common sense to plan for their sleep, but also leaders should be cognisant of the fact that they too need to sleep. They need to sleep when not actively on duty. Fortunately, they have tools for this, but unfortunately this principle is being under-used or wrongly used by most officers in mission command. Mission command is one of the pillars of the Canadian Military Doctrine, and the right utilization of the principle of mission command at every level should help to ensure that each echelon of the chain of command gets enough sleep. Leaders need to apply the mission command principle and

stop using “a 200-mile screwdriver.” By doing so, they have the potential to rest while the other echelon accomplishes the mission.

Also, as demonstrated in the previous chapter, sleep deprivation will create operational limitations for a commander; hence, a better understanding of the leadership’s role is necessary for mitigating the negative impact of the operational tempo. In order to apply common sense and be able to deal with the operational impact of sleep deprived soldiers, the leadership would benefit from understanding the sleep cycle and sleep deprivation, but the only way that this will be done is if it’s endorsed by the Army as a whole and everyone understands that taking a nap prior to an operation can help achieve the desired end state. The battle procedure of the army taught at all levels includes a step of forced rest, unfortunately too often that step is skipped or frowned upon as if soldiers are tough and don’t need sleep. Also, although studies have demonstrated that, yes, soldiers can go up to 72 hours conducting physical tasks without the need of sleep, leaders must understand that after 72 hours, soldiers will have no combat ability until they have recovered.

Sleep management recommendation

The literature review conducted so far reviewing research studies and other nation’s policies has provided important fatigue counter measures and intervention strategies to overcome sleep deprivation, or at a minimum to reduce the negative impacts of lack of sleep on the effectiveness of the unit. The fatigue countermeasures can be divided in two categories: pharmacological and non-pharmacological interventions. The following section will focus on the intervention strategies of those two categories.

Non pharmacological interventions

Researchers around the world have studied lack of sleep for over a century, and they have discovered that there are various methods to prevent or diminish the effect of sleep deprivation using non-pharmacological counter measures. The following section will describe three of the most important strategies that should be included in the development of the Army sleep management policy. These are basic sleep scheduling factors, chain of command responsibilities and individual measures.

Basic Sleep Scheduling Factors

When planning a work rest cycle, there are some basic sleep scheduling factors that need to be taken into consideration. First, the duration of the sleep period is essential. To be optimal, it should be around 7-8 hours; while there is no minimum, it must be recognized that anything below 7-8 hours will result in a degradation of the performance level. Also, timing of sleep is important, as the best quality of sleep will be obtained during nighttime hours (i.e. 11 PM to 7 AM). If a full rest period is not possible, it can be divided in shorter periods, such as 2 blocks of 4 hours, or smaller nap periods. The best times for naps are early morning, early afternoon and of course during night time hours.[142] A common mistake is the assumption that resting is equivalent to sleeping; this is false, they are not the same. Resting will temporarily make the soldier feel better, but it does not restore performance or help with the sleep deprivation effects.

[142] Appendix B: Sleep Management, Sleep Deprivation, Walter Reed Army Institute of Research (2007): 214-219.

Second, there should always be a prioritization of sleep based on the task the soldiers need to accomplish. The priority of sleep should always go to the soldier/leader making critical decisions. As explained earlier, a well-rested soldier will show both speed and accuracy during decision making.[143] This is easier said than done. Canadian Army Officers, like many others, have the motto, "Man ahead of himself," so they tend to sleep less and spend time doing shifts at night to share their soldiers' burden. The mentality of this needs to be changed, because an officer going to get some sleep is not an act of weakness but an intelligent decision. The second priority for sleep scheduling should be for those who have to remain vigilant and need to perform some medium-level mental tasks, like guard duty or equipment operation. Finally, the last priority shall be giving to soldiers only required to perform physical tasks.[144]

Third, there are four ways to capture core sleep, i.e. the amount of sleep necessary to satisfy the minimum sleep requirement. The first has been mentioned numerous times and consist of the individual getting the "right amount "of sleep (7-8 hours for most soldiers) in a continuous period. If soldiers are unable to sleep that long, the anchor sleep, introduced by Minors and Waterhouse[145], could be used to maintain core sleep. The anchor sleep technique divided the required amount of sleep (8 hours) into two 4-hour sleep periods. The intent is to take one of the sleep periods at the same time each day, anchored to a local time which disregards time zone changes.[146] The second period can be taken at a random time when suitable for the operation or mission. The anchor time

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[143] Ibid, 214-219.
[144] Appendix B: Sleep Management, Sleep Deprivation, Walter Reed Army Institute of Research (2007): 214-219.
[145] P. Naitoh, T. L. Kelly, "Minimal Sleep to Maintain Performance: Search for Sleep Quantum in Sustained Operations". *Naval Health Research Center*, Report no.89-49 (1992), 5.
[146] Ibid, 6.

should be maintained during the whole operation or mission, which will help in the stabilization of the circadian rhythm and is easier to manage than a full 7- 8-hour sleep period. Another technique to maximize core sleep is the prophylactic sleep[147]. This includes napping in anticipation of sleep loss and/or sleeping a longer period of time prior to a known sleep deprivation period to store sleep. Unfortunately, with this technique, sleep storage confirmation is not an exact science and the benefits are relatively small but will help the soldier for the first days or so.[148] Another way to gain sleep during an operation and or training is to sleep whenever possible. During sustained operations, soldiers should try to sleep when not on duty, keeping their social lives to a minimum. Those naps can be long or short; even if the soldier has only 10-20 min, there are still some benefits in sleep restoration during those ultra-short naps.

Unfortunately, sleeping does not come easily for everyone; some soldiers can just close their eyes and they are sleeping within minutes, while others will take hours to fall asleep. It is important to note that, when they only have a few hours to sleep, every minute counts. Fortunately, there are some techniques soldiers can use to fall asleep faster. They should try to sleep in a quiet area, because places like the back of a command post is not an ideal location. Soldiers need to be comfortable while sleeping; hence, a room with temperature, noise and light control is the most suitable location to sleep. It is also important to minimize the use of caffeine and nicotine at least 4 to 6 hours prior to a

[147] Ibid, 6.
[148] P. Naitoh, T. L. Kelly, "Minimal Sleep to Maintain Performance: Search for Sleep Quantum in Sustained Operations". *Naval Health Research Center*, Report no.89-49 (1992), 6.

sleep period. Contrary to popular belief, foods and diets alone will not improve sleep but hunger and thirst may disrupt sleep.[149]

Understanding the basic scheduling factors is key in the development of an effective work/rest plan. The previous section proposed various techniques and conditions to maximize the soldier's sleep. The main points are as follows: duration of sleep is an essential condition; while developing the work/rest plan, priority shall be given to those who have the most important decision-making responsibility; core sleep can also be achieved by other means than just 7-8 hours of continuous sleep; and finally, the ambient conditions where the soldiers are sleeping have a tremendous impact on the quality of their sleep.

Chain of Command Responsibilities

As the chain of command controls the planning and execution of operations and training, they have an essential role to play in the implementation of a successful sleep management program, with the work and rest cycle resting partially in their hands. This section will discuss some of the responsibilities of the chain of command in the management of sleep for their soldiers, including the need to follow a work/rest schedule, the factors to look for to prevent sleep deprivation and how to deal with sleep deprived soldiers.

First, the chain of command must be aware of the impact of sleep deprivation on the overall success of the mission and they must understand the importance of sleep and

[149] Appendix B: Sleep Management, Sleep Deprivation, Walter Reed Army Institute of Research (2007): 214-219.

sleep routine in their plan. As discussed in chapter 3, some nations have provided a table of minimum sleep requirements and recovery periods with regards to the type of work the soldiers are doing (physical and/or mental). The author recommends using the Australian data which is well researched as a guideline to the Canadian chain of command. The chain of command should be using those figures as a guideline only and they should be used by taking into account other considerations. First, the table provides a ration for physical work; this should be in a situation where there is no need to use any mental function. However, it should be clear that in a combat situation, mental functions are always required. For example, when digging a trench, if the situation is within an operational setting where the soldier could have to use a weapon, the ability to safely identify the target would be diminished and thus could lead to fratricide or collateral damage. A better example for where the physical task guideline could be used would be filling up sand bags during a domestic disaster relief effort where the need to remain vigilant is not as critical. As a result of this, the recommendation would be to use the mental guideline in every situation where there is a possibility to encounter hostile opposition/forces. Also the chain of command must understand that those guidelines are the minimum but not optimal amount of sleep; whenever possible they should plan to have a 7-8-hour rest incorporated in their battle routine. When the soldiers have been placed in a situation of intense stress where adrenaline was produced, a higher amount of recovery time should be given to the soldier to fully recuperate from the stressful incident. So the table is a useful tool but should be applied with the good judgement of the chain of command.

It is the responsibility of every supervisor to remain vigilant in recognizing the first signs and symptoms of fatigue within their subordinates; this will help prevent future combat ineffectiveness. Every individual is affected differently by sleep deprivation; therefore, it can be difficult to recognize every symptom of fatigue in each individual, but knowing the key ones is essential. There are two main categories of signs: physical (vacant stare and bloodshot eyes, slurred and slow speech) and behavioural (poor work output, poor judgement and confusion). The table provided in the US guidelines in chapter 3 in a great overview of the most common sleep deprivation and fatigue indicators and should be in every supervisor's aide-memoire.

Once the chain of command has identified a soldier in the first stage of sleep deprivation, action should be taken immediately, because the longer you wait the worse the effect and longer the potential recovery period. The remedy for sleep deprivation is simple: sleep. If possible, when soldiers are showing signs of sleep deprivation, they should be given the opportunity to get some sleep. Obviously, that's not always possible so the following are some techniques that the chain of command can use until the soldier receives the proper amount of sleep. When a supervisor acknowledges that he is dealing with a sleep deprived soldier he/she should reassure their soldier rather than placing more pressure on them to get the task done; giving simple directions would prevent forgetfulness and confusion. Supervisors should confirm often with their soldiers to ensure that they understand the orders, and as the lack of sleep increases they should be asked to repeat the instruction/order back to the supervisor. If the task being conducted is critical and needs mental ability, like the calculation of a time fuse for an explosive device, two people should always double check the work. Also, never leave soldiers

alone, regardless of how motivated they are, under lack of sleep conditions. If left alone in a sentry post, the risk of falling asleep is high and the consequences could be catastrophic. Having the soldier rotate within different tasks may temporarily reduce the effect of sleep deprivation, but all those measures are not as effective as getting those soldiers the needed sleep. An important point to note, in order to be in a situation to monitor soldiers, supervisors also need to sleep, because becoming a casualty of sleep deprivation as a leader will only make matters worse. Once again, sleeping while acting as a commander is not weakness; it is common sense.

The involvement of the chain of command is critical in diminishing the effect of lack of sleep. They are key to the implementation of a work and rest cycle, and their judgement is essential in the guideline application of the minimal sleep requirement to remain effective. They must be able to recognize the signs and symptoms of sleep deprivation and they should understand that even though there are mitigating factors to help with the effects of sleep deprivation, the only remedy is a good sleep period as soon as possible when the operational tempo allows it.

Individual measures

To be successful, a sleep management program needs to involve each soldier as an individual; after all, the intent of the program is to minimise sleep deprivation in order to be more effective as a whole. Therefore, the soldier himself has an important role to play in the implementation of the sleep management program. First there is an educational component. Every soldier should be taught the basics of sleep and the symptoms and

consequences of sleep deprivation. In addition, good sleep technique should be covered. Real life situations of combat accidents due to lack of sleep should be used as examples, such as the fratricide incident involving American soldiers in Op Freedom. Soldiers should be sensitive to the benefits of taking a short nap when time permits to self-manage lack of sleep, especially in an environment where sleep is minimal. In continuous operations, "unless what you are doing right now is important, go to bed" should be the number one piece of advice.[150]

A sleep log is also an individual measure that can be used as a sleep management tool. As its name suggests, soldiers are expected to keep track of the amount of sleep they are getting within each 24-hour period. This should be done not only on operation, but also in garrison to establish a baseline of sleep requirement. A check list or mood scale (modeled on the Australian fatigue check list discussed previously) should also be available to the soldier to be able to assess their level of sleep deprivation.

Numerous research has been done to link level of fitness and nutrition to the qualities of sleep an individual gets at night. The army fitness manual promotes a healthy lifestyle with a well balanced physical fitness level and nutrition as key for the soldier's ability to sustain continuous operations during a long mission. Consequently, soldiers should eat well and keep exercising whenever possible.

Lack of sleep can be managed by non-pharmacological means. Basic sleep scheduling techniques can improve the amount of sleep a soldier gets, thereby diminishing the overall sleep deprivation of the whole unit. When planning a work/rest cycle, priority should be given to those who are required to make life or death decisions

[150] U.S. Naval Strike a, Performance Maintenance during continuous Flight Operations.

in a matter of seconds. Also when, where and how much sleep each soldier is getting will greatly influence the level of sleep deprivation of the soldiers. Thus, sleep management is everyone's responsibility, so the chain of command should plan for sleep time but soldiers should also take the opportunity to sleep when they can.

Pharmacological Interventions

A great deal of research has been conducted and is still being done every year to find the perfect drug cocktail to produce a super soldier who can overcome the effects of sleep deprivation. The]is section will briefly discuss some of the pharmacological interventions that are available to the soldier; however, this would only be a rapid overview as the main scope of this paper is to lead to the design of a sleep management program to prevent the lack of sleep. The first section will discuss the main category of drugs (stimulants) to manage sleep deprivation: caffeine. Furthermore, modafinil and amphetamines will be briefly discussed.

Drugs to manage sleep deprivation

Caffeine. Drugs to counteract the effect of lack of sleep have been around for a very long time. The most popular and widely used by most soldiers around the world is caffeine. Some people can be physically addicted to caffeine; they need their daily morning coffee to be functional. Others use it to be able to stay awake during a long drive or to remain attentive during a lecture, but all those people have one thing in common: they are using a stimulant to overcome the effect of fatigue. Caffeine products come in a

variety of sizes and formats, from coffee to chocolate and even a special caffeine gum. The use of caffeine is not regulated and soldiers are free to use it as seen fit. Does caffeine really help the soldier overcome the effect of sleep deprivation? The simple answer is yes, the Committee on Military Nutrition Research (CMNR) in the United States has reported that caffeine (between 100 and 600 mg) can help maintaining cognitive performance in situations of sleep deprivation.[151] Their conclusion was based on a series of research studies conducted at numerous institutions, including military research facilities, that demonstrated that caffeine improves vigilance. The important aspect to remember about caffeine as a countermeasure for sleep deprivation is that it is for short term use only, for a maximum of three days and it does not replace sleep. Soldiers, however, need to be aware that caffeine in liquid form will increase urine output, so when they finally get some time to sleep, their sleep will likely be affected by the need to use the washroom; therefore, the recommended form of caffeine should be in pills/tablets and any non-liquid form, like chocolate.[152]

Modafinil. There are two mores grand categories of stimulants that are being studied and have shown some positive results in helping soldiers overcome the effects of sleep deprivation: modafinil and amphetamines. Modafinil as a prescription drug has been approved by the US Food and Drug Administration as a treatment for shift worker sleep disorder. The military testing of drugs has shown that modafinil "has the ability to promote wakefulness and to improve cognitive performance during sustained periods of

[151] Tom M. McLellan, The impact of caffeine on cognitive and physical performance…, 48.
[152] Appendix B: Sleep Management, Sleep Deprivation, Walter Reed Army Institute of Research (2007):216.

sleep deprivations associated with military operations."[153] Unfortunately, to date all studies of modafinil for military operations use have been conducted in field/lab study; therefore, more study in operational settings is needed before this drug receives a wider approval for its use by the military.[154]

Amphetamines. The last stimulant category to be discussed will be amphetamines. Studies show that "relative to placebo amphetamines improve vigor and reaction time performance during sleep deprivation period."[155] Military pilots under medical control have been studying and/or using amphetamines for well over a decade. There is some controversy for dexamphetamine (a form of amphetamine), however, which is currently being studied, primary reports indicate that the drug negatively affects the post-deprivation sleep architecture.[156]

Consequently, those two categories should not be part of the Army sleep management program, as they need medical supervision and have not yet been approved. As a result, the only pharmacological countermeasure that should be endorsed, but with caution, by the Canadian Army to counter sleep deprivation is the limited used of caffeine for short term sleep deprivation.

Operational Stages Recommendation

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[153] Kelli Westcott, "Modafinil, Sleep Deprivation, and Cognitive Function in Military and Medical Settings", Military Medicine (170, 2005):334.
[154] Ibid, 334.
[155] Julian Lim, Sleep Deprivation and Vigilant Attention, 316.
[156] Lynn Caldwell, Caldwell john, "Recovery sleep and performance following sleep deprivation with dextroamphetamine.", *Sleep Res (Vol6, 1997):92-101.*

The next section will discuss recommendations on how to structure a sleep management program in accordance with operational stages. Over the last decade, most of the Canadian Armed Forces doctrine at the operation level has been changed to reflect the same operational stages for ease of planning and common understanding between all elements. Therefore, all planning and all joint publications are now based on the following operational stages: planning, preparation, buildup, execution and termination, these stages in their description are similar to the US phases discussed in chapter 2. To remain in line with the operational terminology adopted by the CAF, the sleep management program, even though specifically designed for the army, should follow the same stages. The following section will provide sleep management methods and consideration for the various stages of the operations. The recommendations made are a result/compilation of all information provided in this chapter and/or previous chapters.

Planning/Preparation

The first two phases of the operation stage can be summarized as the redeployment phases. These include all activities conducted prior to the actual deployment of troops in the theater of operations. During the planning/preparation stages, the following sleep management considerations should be undertaken.

- Education: This is where the chain of command and soldiers should be taught or re-taught about the importance of sleep and sleep management. The Chain of Command should review and start planning their in-theater work/rest cycle.

- Individual measures to counter the impact of sleep deprivation should be started prior to the deployment. Soldiers should try to get as many as 10 hours sleep per day and should try to go to bed early and wake up early versus going to bed late and waking up late. Maintaining a high level of physical fitness and proper nutrition is also essential.
- Practice is the best medicine; therefore, soldiers should try to get used to the future sleep condition they will be facing, especially if they will be required to sleep in a new environment such as cramped quarters on a ship or in chemical protective garments. Also, if soldiers will be required to work at night prior to departure, they should adjust their schedule to mimic the one of the operational deployment.
- The Chain of command should ensure a high level of job skills. When fatigue increases, instinctive reaction to any combat situation is primordial. Also redundancy in skill is essential to be able to give soldiers rest if needed.

Buildup

The buildup phase is the actual deployment of troops into the new theater of operation. This phase will not start at the same time for each soldier and the flow of soldiers arriving in the theater should be planned very carefully to allow each individual proper time to recover from jet-lag and to adjust to the new routine before the start of the mission. During this phase, a pre-planned work-rest-sleep schedule should be followed as

closely as possible in order for the troops to reach combat effectiveness as soon as possible.

Execution

The execution phase is where the lack of sleep can affect the success of the mission. Ensuring all soldiers get a minimum amount of sleep is a must. The Chain of command and individuals themselves must use all strategies described above to minimize the negative impact of lack of sleep. A well-developed and regular reassessment of work/sleep will help avoid a situation where all personal are physically or mentally exhausted at the same time. Personnel should take advantage of any opportunity to sleep to be ready for the next round of sleep deprivation. As little as 10 minutes of sleep can be beneficial in the long run. And if time permits, exercising will also help with the negative impact of sleep deprivation. In addition, the chain of command themselves need to ensure that they are also getting the required amount of sleep to remain functional. After a situation of intense combat and/or a situation where soldiers' adrenaline was high, recovery time should follow as soon as possible. When the adrenaline leaves the body, intense fatigue will follow. During the execution phase, the works limit table should be followed: as a minimum, each solder should receive 1.5 hours of sleep after 24 hours and 3 hours of sleep after 72 hours. The author argues that in a theater of operation, the minimum standard for sleep should be where mental tasks are required, as the soldiers could be faced with the decision to fire their weapons, where they need to positively identify the target (i.e. a mental task).

Mainly Mental Tasks		
Acceptable performance (days)	Sleep required (uninterrupted)	Suggested recovery period
1	0	8-12 hrs
2	1.5 hrs per day	12-24 hrs
3	3 hrs per day	24 hrs

Table 4.1 Deployment Minimal sleep requirement.[157]

Termination

Termination is the last operational stage, involving the redeployment of the soldiers back to the home base. After a deployment, soldiers should be given sufficient time to recover from the lack of sleep. They need about 10-12 hours of sleep for 2-3 days to fully recover.

Dividing the sleep management into the operational phases will help the chain of command and individuals to better prepare for the mission and to better understand how to prevent and/or limit the effects of sleep deprivation on the overall mission.

Conclusion

Sleep deprivation will occur at some point during a sustained operation; however, the impact of it will greatly depend on how it is managed in theater. This chapter

[157] Australian Defence Force, Fatigue Management During Operation..., 1-97.

provided strategies and recommendations that should be included in the future Canadian Sleep Management Guidelines.

Understanding the basic scheduling factors is key in the development of an effective work/rest plan. The previous section proposed various techniques and conditions to maximize the soldiers' sleep. The greater the mental (decision-making) responsibility of the individual, the greater the amount of sleep they should receive and they should be a priority over the soldier who has little mental responsibility. Also, the chain of command is critical in diminishing the effects of lack of sleep. They are the instigator in the implementation of an efficient work-rest-sleep cycle. At the same time, no matter how good their planning is, soldiers may still suffer from lack of sleep; thus, they need be able to recognize the signs and symptoms of sleep deprivation. Finally, but not the least, the involvement of individual himself is essential in fighting the negative impacts of lack of sleep, as they may be the first one to recognize the effects of sleep deprivation.

Second, this chapter provided a quick overview of the pharmacological interventions that can be available to the soldier. Only one, caffeine should be discussed in the guidelines. It has been proven that caffeine can temporarily diminish the effects of sleep deprivation, but only during a short period of time ranging from 2-3 days. The other two pharmacological drugs, modafinil and amphetamines are under prescription only and require close monitoring from medical staff. As a result, these are not a strategy available to the individual and/or the chain of command.

Finally, recommendations were made to align the sleep management recommendation with the current operational stages. For each stage, recommendations

were given to the individual and the chain of command to better manage sleep deprivation.

So far this paper has provided an extensive background on the fundamentals of sleep, sleep requirements and the effect of sleep deprivation in chapter 1. A detailed literature review covering the past 60 years of research investigating sleep deprivation for periods over 24 hours was conducted in chapter 2. The current Canadian army policy with regard to sleep management was reviewed and compared to the Australian and American policies in chapter 3, and this chapter provided recommendations for how and what should be included in our new sleep deprivation management guidelines. The pinnacle has been reached and this paper will now conclude with the way ahead, with the author's skeleton point form for the future development of the Sleep Management Guidelines.

CONCLUSION

Sleep deprivation during military operations can have disastrous consequences on the mission; sleepy soldiers are less efficient and tired officers will quickly lose their ability to make sound judgements. Therefore, the Canadian military, like many others, ought to have a program and guide to help mitigate the effects of the lack of sleep. The Canadian Air Force has a well-established crew rest policy, while the Royal Canadian Navy is always trying to improve their shift working schedule; however, the Army has done very little. The Army has published a minimal amount of information on sleep deprivation in its Standing Operating Procedures for Land Operations. One of the statements in the SOP was that soldiers are expected to remain effective for physical tasks for up to 72 hours. But it fails to provide more information on what exactly the soldier can be asked to do and how well they would be performing during that 72-hour period. The author's position was that expecting our soldiers to still be combat effective after 72 hours of sleep deprivation, although possible, will have a severe impact on the mission and the following tasks that they can successfully accomplish.

Chapter one provided an overview of sleep deprivation theory, focusing on basic sleep deprivation information and sleep requirement architecture. The most important points to remember are that an average soldier requires 7-8 hours of good sleep every 24 hours to be fully effective. Also their sleep should be taken in accordance with the circadian cycles (i.e. at night). The soldier's performance (mentally and physically), mood and alertness will be affected by the lack of sleep. And even the best soldier will experience episodes of involuntary micro sleep during an extended period of sleep deprivation.

Chapter two provided an extensive literature review focusing on the effects of sleep deprivation on performance, including decision-making, task awareness and physical performance in field and lab settings. Researchers agree that the ability to conduct mental work declines by 25% per each day of sleep deprivation; in other words, after 48 hours' sleep deprivation, the mental ability of the senior leadership of the military forces would only be at 50% of their total capability. With regards to physical capability, studies have demonstrated that sleep deprivation alone does not significantly impair physical work ability. However, exercise compounded with sleep deprivation increases negative mood disturbance and reaction time. Also studies have demonstrated that following 72 hours without sleep, a soldier will require a significate amount of recovery time. To invalidate the SOP statement, one should keep in mind the study conducted on a firing range after 72 hours sleep deprivation in which soldiers were still able to fire their weapons but had lost the ability to properly conduct target discrimination prior to engaging, demonstrating that after 72 hours troops in combat are no longer combat effective. Therefore, only in a situation where no weapons are involved would it be true that soldiers are effective up to 72 hours without sleep. To conclude, the first two chapters were instrumental in providing the background and literature to demonstrate that after 72 hours sleep deprivation our soldiers are in fact combat ineffective.

After invalidating the current Army SOP, the next step was to provide a new army guideline for sleep management. Chapter 3 provided an examination of other nations' policies with regards to sleep deprivation to see how they cope with sleep deprivation on operations. The chapter concluded with format recommendations to be used in the development of the new guide.

- The table of sleep requirements needs to include both physical and mental task requirements, but there is a danger with giving a maximal/minimal amount of sleep required.
- A fatigue checklist is needed to determine the state of sleep deprivation of a soldier.
- Simplicity in the manual is key for a better understanding from all soldiers; however, explanations are needed to properly identify the effects of sleep deprivation.
- Having a set figure of sleep requirement is not always the focus of sleep management but rather strategies and ideas.
- Fatigue management is a responsibility at all levels of command including the individual.
- A phase approach of sleep deprivation using the doctrinal phases of operation should be used.
- Individuals should use techniques to self-manage sleep deprivation, like the rest/work cycle plan, self-diagnostic techniques and good sleep skills to achieve the individual quantum of sleep as needed.
- Caffeine impact on sleep deprivation.

And finally, the last chapter focused on further recommendation on how to manage sleep deprivation using a combination of sleep factors, including scheduling, chain of command responsibility and individual responsibilities. The chapter also quickly touched on the topic of drugs used to manage sleep deprivation, but recommendations

were made not to discuss those drugs, except for caffeine, in the management guide, as they need medical supervision.

Sleep deprivation is an aspect of any combat mission that needs to be addressed at every level of command. The current SOP is outdated and does not provide sufficient information to prevent and mitigate the negative effects of sleep deprivation. Further developing the proposed guidelines should provide the Army with a very well taught and researched sleep management program that is comparable to those of our closest allies.

Way Ahead

The most importance take away from this paper is that sleep management is a leadership responsibility. Military leaders and commanders have the unique responsibility to provide a combat effective unit/section and as such, ensuring that their soldiers receive an appropriate level of sleep falls, upon them. In order for this to happen the whole Army leadership needs to embrace sleep management as a leadership function. As a result, a twofold approached is needed, first there is a need to write and publish new guidance on the topic and second, there is a need to incorporate the sleep management guidance into our doctrine, thus reflecting the leaders' obligation for sleep management and then factoring it into our training.

This paper has provided the necessary information and recommendations to further develop a Canadian guide. Thus, the author is proposing that the new army guidelines be divided in 5 parts and cover the follow topics.

Part 1: Basic sleep Information.

This section should give the reader enough information about the basics of sleep and what is sleep deprivation. The aim is to educate the reader but not to overload him with very specific information. The following is a list of topics that should be discussed. When possible and relevant, information should be in table form.

- Stages of sleep
- Circadian cycle/rhythm
- Sleep inertia
- Sleep requirement, individual need for sleep
- Sleep deprivation effect (to include type of sleep deprivation and effect)
- Impact and consequences of sleep deprivation.

Part 2: Fatigue in Military Operations.

This section should focus on the causes and signs of fatigue specific to a military environment. In order to provide the reader with research context, a few milestone studies should be briefly explained. Also, a table of cause and effect of sleep deprivation should be available to the reader. Furthermore, to give more context, one or two example of real life sleep deprivation incidents should be included. Here is a proposed list of topics for part 2.

- Short literature review with real life example
- Symptoms of sleep deprivation (1 to 7 Days)
- Effects of sleep deprivation on performance
    - Mental ability reduction 25% per 24 hours without sleep
    - Decision-making
    - Physical fitness
- Discuss some of the studies
    - correlation between rank/HQ level and sleep
    - Inability to properly ID target after 72 hours sleep deprivation

Part 3: Chain of Command Responsibility.

The section should cover the involvement of the chain of command in diminishing the effects of lack of sleep on their soldiers. They are key in the implementation of a work and rest cycle and their judgement is essential in the guideline application of the minimal sleep requirement to remain effective. This section will enable them to be able to recognize the signs and symptoms of sleep deprivation.

- Elaboration/implementation of work-rest-sleep cycle
- Recognizing the first signs and symptoms of fatigue
- Minimum sleep requirement table, with caution
- How to deal with sleep deprived individuals
- Chain of Command also needs sleep

Part 4: Individual Responsibility.

This section should cover the individual responsibility to mitigate the impact of lack of sleep on the overall mission. It should include individual measures such as the use of a sleep log or the sleep deprivation checklist/test.

- Sleep log
- Proper sleeping habit
- Use of caffeine
- Fatigue checklist

Part 5: Sleep Management During Each Operational Phase.

Dividing the sleep management into the operational phases will help the chain of command and individuals to better prepare for the mission and to better understand how to prevent and/or limit the effects of sleep deprivation on the overall mission. This section

will focus on giving recommendations on sleep management during each operational phase as described in chapter 4. It should be broken into the following topics:

- Planning/Preparation
  - Education
  - Individual measures to counter the impact of sleep deprivation
  - Practicing sleep deprivation
  - Specific Chain of Command and individual responsibilities
- Buildup
  - Need for pre-planned work-rest-sleep
- Execution
  - Sleep minimum requirement table
  - Benefits of naps
- Termination
  - Recovery time needed.
- Drugs
  - Caffeine
  - Danger with unapproved drugs

This guide should provide most of what the leadership at all levels need to know to manage sleep deprivation in order to maintain combat effectiveness; however, the sole publication of a guide won't necessarily solve the problem. While it is a required step, it is not the only one needed in the process of truly understanding and being pro-active at managing sleep. That being said, there are a few steps that if done in conjunction with the guide, has the potential to greatly enhance our understanding and practices for sleep management. First, there is a need to ensure that relevant information is formally included across the full spectrum of training; from individual training during the Common Army Phase (CAP) for officers or during the occupational courses for non-commission members, to collective training at the sub-unit, unit, and brigade levels. When designing yearly unit training, unit commanders should review theoretical sleep management training the same way they review ethics or ROEs. Also, the actual sleep management

practice should be applied and assessed during large scale exercises like the ones conducted in Wainwright.

Second, reports on sleep management and the degree of sleep deprivation should be included in routine reporting when conducting operations and during training. We have SOPs established to report the status of our vehicles, weapons and major equipment. We also currently report on how many personnel are available for duty, however, we do not report on their state of readiness as it pertains to sleep deprivation and effectiveness. Currently, even if soldiers have been conducting operations non-stop for days, we still include them in the personal report (PERSREP), giving the wrong picture to the Chain of Command. With this in mind, new SOPs on reporting personal should be developed that include the operational capacity of those soldiers. At the end of the day a commander with a Vehicle Operational Report of 80% is no good if all the soldiers on the PERSREP are sleep deprived to the point of ineffectiveness.

To conclude sleep management is a leadership responsibility that has to be embraced by all. This paper provides a road map for the development of a new guide taking into consideration a multitude of research conducted over the past century and taking into account how our allies have approached the problem. The guide is the first step in the sleep management program but more work is still required by the Army Headquarters Staff to incorporate sleep management into our doctrine and implement this into Army training and operations.

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