Sleep Patterns and the Impact on Performance: A Study of Men and Women Enrolled at the United States Military Academy

Nita Lewis Miller
Naval Postgraduate School
Monterey, CA 93943

Lawrence G. Shattuck
Jennifer K. Clark
United States Military Academy
West Point, NY 10996

Sleep requirements of adolescents and young adults are distinct from those of other age groups due to differences in the circadian rhythms of the sleep-controlling hormone, melatonin. This study examined the sleep patterns of cadets during their first year of training and study at the United States Military Academy (USMA). The study population included the entire USMA class of 2007 (n ~ 1300) and a small group of upperclassmen (n=40). Actigraphy was recorded on a sample of the class (n=80). Survey results compared sleep patterns prior to reporting to USMA with sleep patterns during Cadet Basic Training and during the Fall semester, 2003. This baseline data collection effort sets the stage for follow-on interventions that will attempt to rectify inadequacies in the sleep patterns of cadets.

INTRODUCTION

In the future, the soldiers in the US Army will be equipped with advanced technology that promises to provide more data and more information. The pace of warfare continues to increase and operational tempo (OPTEMPO) has reached the point where continuous (24-7) operations are the norm. Military commanders have never been immune from the effects of sleep deprivation (Shay, 1998). It is essential that the cognitive functioning of military personnel continue unimpeded, but a preponderance of scientific evidence now shows that human perception, cognition and decision making suffer when people are sleep deprived (Belenky, Wesensten, Thorne, Thomas, Sing, Redmond, Russo, & Balkin. (2003, Van Dongen, Maislin, Mullington, & Dinges, 2003).

The present study is part of a longitudinal research effort that will investigate sleep patterns of cadets at the United States Military Academy (USMA) over a four-year period. Additionally, the study serves as a test bed for examining sleep and performance in the Future Force/Future Soldier. These two groups share many similarities: they are approximately the same age; they both work in an environment with a high cognitive demand; and, both groups are self-selected to serve in the military.

Writers of recent military doctrine have acknowledged that loss of sleep is among the factors that directly contribute to poor performance. For example, a US Marine Corps publication states the following. "Combat and combat-related military missions can also impose combinations of heavy physical work; **sleep loss;** dehydration; poor nutrition; severe noise, vibration, and blast; exposure to heat, cold or wetness; poor hygiene facilities; and perhaps exposure to infectious diseases, toxic fumes or substances. These, in combination with other influences—such as concerns about problems back home—affect the ability to cope with the perception of danger, and diminish the skills needed to accomplish the mission." (US Marine Corps, 2000).

This same Marine Corps publication discusses the impact of the stress caused by the factors mentioned above. It states that the most common stress reactions include:

- Slow reaction time
- Difficulty sorting out priorities
- Difficulty starting routine tasks

- Excessive concern with seemingly minor issues
- Indecision, difficulty focusing attention
- A tendency to do familiar tasks and preoccupation with familiar details
- Loss of initiative with fatigue and exhaustion

However, the prevailing culture within the US military tends to be one in which depriving oneself of sleep is a means of demonstrating commitment to the mission and the organization, as well as physical toughness. In a recent interview, a high ranking US Army officer was asked how much sleep he thought leaders needed each day during sustained operations in order to be effective. He responded by saying that about 3½ hours of sleep every 24 hours would be enough to sustain a leader indefinitely. Empirical findings do not support his response.

Belenky et al. (2003) conducted a study in which 66 participants (ranging in age from 24 to 62) were randomly divided into four groups. After three days of baseline testing on a psychomotor vigilance task, the groups received either three, five, seven or nine hours of sleep for seven days. At the end of the seven days, the groups were permitted to sleep eight hours per night during the recovery phase of the study. Participants were administered the psychomotor vigilance task (PVT) throughout seven days of sleep restriction and three days of recovery sleep. By the seventh day of the sleep restricted period, the performance of the three-hour group was only 50% of baseline performance. Even after three days of recovery sleep, the three and five-hour groups were unable to achieve performance levels commensurate with baseline levels.

A related study by Van Dongen, Maislin, Mullington, and Dinges (2003) examined performance from individuals assigned to three different levels of sleep deprivation: four, six, and eight hours per night. Performance was tracked over 14 days of sleep restriction. In this same study a separate group was totally sleep deprived for three days and their performance was also recorded. After two weeks of sleep restriction, performance in the four and six-hour groups was equivalent to that of individuals who had been totally sleep deprived for two or three nights of sleep. Another important finding from this study was that although cognitive performance was degraded in all sleep conditions, high ratings of subjective sleepiness were reported only in the group with the most severe sleep restriction.

Findings from these studies demonstrate the profound effect of both acute and chronic sleep loss on cognitive performance. Recovery from severe sleep loss will not occur overnight or even after three nights of normal sleep. The studies allude to the insidious nature of chronic sleep deprivation: although performance is severely degraded, only those in the most severely restricted group report being sleepy.

The relationship between memory and sleep is especially important when studying this population. Increasing evidence supports the idea that sleep is a requirement for effective learning and memory (Fenn, Nusbaum & Margoliash, 2003; Walker, Brakefield,, Hobson, & Stickgold, 2003; Gais, Plihal, Wagner, & Born, 2000; Stickgold, James, & Hobson, 2000; Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994; Wilson & McNaughton, 1994).

Many soldiers are essentially adolescents when they enter the military service. Research has shown that the sleep requirements of adolescents and young adult are distinctly different from those of other age groups (Carskadon, 2002, 2003; Wolfson & Carskadon, 1998, 2003; Carskadon, Wolfson, Tzischinsky, & Acebo, 1995; Carskadon & Dement, 1983). The circadian fluctuation of the naturally-occurring hormone, melatonin, differs in adolescents and young adults and is thought to reflect the underlying processes that control sleep patterns. In this population, melatonin is released later. Consequently, this population tends to go to bed later, but is less able to wake up early in the morning.

Cadets at USMA have limited opportunities for sleep. Unlike other college populations, their first formation is at 0640 but many cadets are awake long before that hour to participate in athletic activities. In addition, they are required to attend all academic classes and meals, leaving few chances for naps and catch-up sleep. These cadets almost certainly get less sleep than their peers at non-military institutions. Under these conditions, many types of performance are likely to be degraded including performance in academic, athletic and military domains.

METHOD

Participants

In the present study, survey data were obtained from all members of the USMA Class of 2007 (n ~ 1300). A stratified sample of the class was selected to wear wrist activity monitors (WAMs). This sample consisted of 80 cadets who were selected to ensure the desired representation of gender, unit (company to which the cadet was assigned), and athletic status (participation on either an intramural or an intercollegiate athletic team). At the beginning of the study, all members of the Class of 2007 ranged in age from 17 to 22. An additional 40 members of two upper classes participated in a portion of the study. These members of the Classes of 2004 and 2005 served as cadre who supervised the instruction and training of the Class of 2007 during their initial summer training. The upper class cadets ranged in age from 19 to 25. Cadre members only participated in half of the six-week CBT. Of the 40 cadre members, 20 participated in the 1st half (1st Detail) of the training and 20 participated in the 2nd half (2nd Detail) of the training. Cadre members were selected to participate based on both gender and the leadership echelon to which they were assigned (squad, platoon, company, regiment).

Equipment

Wrist activity monitors developed by the Mini Mitter Company were used to collect sleep data from the cadets. Data from the wrist activity monitors were analyzed using Mini Mitter's Actiware software program. The software facilitated the calculation sleep duration, sleep efficiency, and sleep latency. Data from selected cadets were entered into the Fatigue Avoidance Scheduling Tool (FAST) package. FAST is based on the human fatigue model selected by the Department of Defense, called the Sleep and Fatigue Task Effectiveness model (SAFTE). The FAST program and the SAFTE Model are patented by Dr. Steve Hursh of SAIC and are used to predict cognitive effectiveness from a given individual's actigraphy. The activity log used by the cadets was developed by the authors and tailored to the environment at the Academy.

Procedures

Young men and women enter the United States Military Academy during the summer and participate in six weeks of Cadet Basic Training (CBT). Members of the Class of 2007 reported for duty on July 30, 2003. All members of the Class were surveyed within 72 hours upon entering the Academy. The survey asked participants for basic demographic data and information about their sleep patterns during the month prior to them arriving at the Academy. They were also asked to provide information about their use of tobacco products, their intake of caffeine, and any over-the-counter or prescribed medications they had taken recently. The 40 cadre members from the Classes of 2004 and 2005 also completed a demographic survey at the beginning of CBT. Another survey was administered to all members of the Class of 2007 and the 40 cadre members from the Classes of 2004 and 2005 at the end of CBT.

Eighty members of the Class of 2007 wore WAMs throughout CBT. Twenty cadre members wore WAMs during 1st Detail of CBT and another 20 cadre members wore WAMs during 2nd detail of CBT. The same 80 members of the Class of 2007 also wore WAMs for 30 days during the Fall academic semester. During the 30 days wearing the WAMs, the cadets were also asked to fill out an activity log. The log divided each day into 15 minute segments. Cadets entered single-letter codes to indicate the type of activity in which they were engaged for each 15-minute segment. As part of this longitudinal study, these same 80 members of the Class of 2007 will wear the wrist activity monitors for a 30-day period each semester through Spring 2007. This paper focuses only on results of the summer and Fall semester sleep patterns.

RESULTS

Data from Summer 2003

Initial demographic surveys were completed by 1290 members of the Class of 2007 (>98% compliance) and by 40 cadre members from the Classes of 2004 and 2005 (100% compliance). Surveys administered at the conclusion of CBT were filled out online. As a result, compliance rates for new cadets and cadre were much lower (72% and 59%, respectively). Survey data indicate that most members of the Class of 2007 reported bedtimes of between 11:00 pm and 1:00 am during the 30 days prior to their entry to the Academy. Most reported wake times between 8:00 am and 10:00 am. The average amount of sleep reported was 8.39 hours (s.d. = 1.62).

During CBT, activities of the members of the Class of 2007 were mandated by a daily training schedule. This schedule indicated that these cadets were to be in bed from 10:00 pm until 5:00 am, affording them not more than seven hours of sleep per night. The training schedule indicated cadre members were to be in bed from 11:00 pm until 5:00 am, affording them not more than six hours of sleep per night. However, nearly all cadets received less than the maximum amount of possible sleep because of the demands placed on them by the rigors of CBT. Amount of sleep received by cadre ranged from an average of 4.0 hours per night to 6.5 hours per night (mean = 5.0). Cadre at the company echelon received the least amount of sleep (mean = 4.6) whereas cadre at the platoon level received the most amount of sleep (mean = 5.4), though the difference between these two groups was not statistically significant. Analysis revealed that cadets in the Class of 2007 who were wearing WAMs received an average of 5.5 hours of sleep per night.

Data from Fall Semester 2003

Eighty members of the Class of 2007 wore WAMs from mid-November 2003 through mid-December 2003. They also maintained activity logs. This period included two weeks of normal academic activities, Thanksgiving week, and a week of final examinations. Data the bedtime, wake time and actual sleep as determined by actigraphy are shown in Table 1 below.

Not unexpectedly, cadets went to bed later and slept in on weekends as compared to school nights. On average, cadets received less than five hours of sleep on school nights, considerably less than the 8.5 to 9.25 hours recommended by sleep experts.

Table 1. Average Actual Sleep, Bedtime and Wake Time by School Night Condition

	School Night	Non-school Night	Combined
Actual Sleep	4:50 s.d.=1:15	6:32 s.d.=2:18	5:20 s.d.=1:48
Bed time	00:31 s.d.=1:18	01:40 s.d.=2:03	00:51 s.d.=1:39
Wake time	5:56 s.d.=0:45	09:08 s.d.=2:28	06:53 s.d.=2:05

DISCUSSION

Survey data from CBT indicate that the members of the Class of 2007 are fairly typical for their age group with respect to the amount of sleep they require. According to Carskadon (2002), adolescents require 8.5 – 9.25 hours of sleep per night. As stated above, prior to arriving at the U.S. Military Academy, members of the Class of 2007 self-reported that they received, on average, 8.39 hours of sleep per night. However, during CBT, their average sleep dropped to 5.5 hours per night, a 34% reduction. The bed times and wake times they reported prior to arriving at the Academy were consistent with the circadian pattern of melatonin in adolescents. The CBT schedule required them to go to bed prior to their natural elevation of melatonin and wake up prior to its decline.

This dramatic reduction in sleep coupled with the shift in bedtime and wake times is a contributing factor to less than optimal physical and cognitive performance. Data from the Spring semester, which will be included in future analyses will continue to examine sleep patterns the Class of 2007. Attrition data and academic and performance data will also be discussed.

The findings of the initial portions of this longitudinal study are important because they are the basis for formulating interventions that could lead to improved sleep patterns among cadets. For example, educating cadets and administration on the desirability and efficacy of naps, including timing and duration, could begin to address this problem. Also, modifying certain Academy policies might provide cadets the opportunity to get more contiguous sleep at night and reduce their reliance on naps during the day. Another possible intervention might be to provide adequate window shades which would decrease light exposure during the day, thereby improving the quality of sleep and nap episodes of cadets.

The findings also have implications for soldiers in the field. When soldiers are stressed due to continuous operations they will experience decrements in performance similar to cadets. Interventions that have been successful at the U. S. Military Academy may be used to improve the quality and quantity of sleep experienced by soldiers in the field.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the valuable contributions provided by the following individuals: Mary Jane Ward, Dan B. Miller, Daniel Neverosky, Aileen Kenney, Domenick Giordano and Mark Reed. This study was funded by PEO Soldier and the Naval Postgraduate School.

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