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Increased risk of upper respiratory infection in military recruits who report sleeping less than six hours per night

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Key Words: sleep duration, common cold, illness, basic training, lost training

ABSTRACT

Introduction: Professional sleep associations recommend 7−9 hours of sleep per night for young adults. Habitually sleeping less than 6 hours per night has been shown to increase susceptibility to common cold in otherwise healthy, adult civilians. However, no investigations have examined the importance of sleep duration on upper respiratory tract infection (URTI) and loss of training days in military recruits. The purpose of this study was to describe self-reported sleep duration in a large cohort of military recruits and to assess the relationship between reported sleep duration and incidence of URTI's. We hypothesized that recruits who reported sleeping less than the recommended 7-9 hours per night during training suffered a greater incidence of URTI and, as a consequence, lost more training days compared with recruits who met sleep recommendations. **Materials and Methods**: Participants included 651 British Army recruits aged 22 ± 3 years who completed 13 weeks of basic military training (67% males, 33% females). Participants were members of 21 platoons (11 male, 10 female) who commenced training across four seasons (19% winter, 20% spring, 29% summer and 32% autumn). At the start and completion of training, participants completed a questionnaire asking the typical time they went to sleep and awoke. Incidence of physician-diagnosed URTI and lost training days due to URTI were retrieved from medical records. **Results**: Self-reported sleep duration decreased from before to during training (8.5 ± 1.6 vs. 7.0 ± 0.8 hours; $P < 0.01$). Prior to training, 13% of participants reported sleeping less than the recommended 7 hours sleep per night; however, this increased to 38% during training ($X^2 = 3.8$; $P = 0.05$). Overall, 49 participants (8%) were diagnosed by a physician with at least one URTI, and 3 participants (<1%) were diagnosed with two URTI's. After controlling for sex, BMI, season of recruitment, smoking, and alcohol, participants who reported sleeping less than 6 hours per night during training were four times

more likely to be diagnosed with URTI compared with participants who slept 7−9 hours per night in a logistic regression model (OR 4.4; 95% CI, 1.5–12.9, *P* <0.01). On average, each URTI resulted in 2.9 ± 1.5 lost training days. Participants who were diagnosed with URTI had more overall lost training days for any illness compared to participants who did not report a URTI during basic military training (3.3 ± 1.9 vs. 0.4 ± 1.3; *P* <0.01). **Conclusion**: In a large population of British Army recruits, these findings show that more than one third of participants failed to meet sleep duration recommendations during training. Furthermore, those who reported sleeping less than 6 hours per night were four times more likely to be diagnosed with an URTI and had more lost training days due to URTI. Since sleep restriction is considered a necessary element of military training, future studies should examine interventions to reduce any negative effects on immunity and host defense.

INTRODUCTION

The National Sleep Foundation, American Academy of Sleep Medicine, and Sleep Research Society recommend that young adults sleep 7-9 hours per night for health, well-being, and optimal neurocognitive function.[1,2] Previous research in a small U.S. cohort (n = 64) has shown that military recruits generally do not meet this recommendation, sleeping an average of 5-6 hours per night.[3] Although sleep restriction is considered a necessary part of military training, it has been shown to impair physical performance, marksmanship, and attention during military tasks.[3] Inadequate sleep duration has been shown to impair immune function, raising the risk for both acute infections and chronic disease.[4] Sleep restriction may increase susceptibility to illness by activating the hypothalamus-pituitary-adrenal axis and sympathetic nervous system.[5] These changes disrupt normal circadian rhythm and immunoregulatory hormone release, inducing a systemic low-level state of inflammation that reduces the body's local immune defense to infection. For example, it has been shown that habitually sleeping less than 6 hours per night increases susceptibility to common cold following exposure to rhinovirus in a civilian population.[4] However, research has not examined the relationship between sleep and upper respiratory tract infection (URTI) in military personnel and how illness affects training. Typically, each adult experiences two to four URTI episodes per year,[6] with the highest rates during the autumn common cold season. Compared to civilians, military recruits reportedly experience a three to four times greater prevalence of respiratory infection due to co-habitation, intense physical training, and potentially sleep restriction.[7] Military recruits who contract an URTI lose valuable training time, hindering their individual progression and increasing medical burden and financial cost of lost training time.

Disruptions in sleep patterns have effects on immune function that may directly impact performance and increase discharge rates in military training. To date, no investigations have examined the importance of sleep duration on URTI and subsequent loss of training days in military recruits. Therefore, the purpose of this study was to describe self-reported sleep duration in a large cohort of British Army recruits in basic military training to assess the relationship between reported sleep duration and incidence of URTI's. We hypothesized that recruits who reported sleeping less than the recommended 7-9 hours per night during training suffered a greater incidence of URTI and, as a consequence, had more lost training days than recruits who met sleep recommendations. This is the first large study to categorize chronic reported sleep duration in male and female military recruits and identify associations with illness and lost training across all four seasons.

MATERIALS AND METHODS

Participants

Participants were 651 British Army recruits aged 22 ± 3 years who completed 13 weeks of basic military training. Male recruits (n = 438; body mass 76.1 ± 10.0 kg; height 1.77 ± 0.06 m; BMI 24.2 ± 2.7 kg·m^{-2}) completed the Combat Infantryman's Course (Line Infantry) at the Infantry Training Centre Catterick, UK. Female recruits (n = 213; body mass 65.1 ± 8.4 kg; height 1.66 ± 0.06 m; BMI 23.7 ± 2.5 kg·m^{-2}) completed the Common Military Syllabus for Standard Entry Recruits at the Army Training Centre Pirbright, UK. Study participants provided fully informed written consent in the first week of training. Ethical approval was obtained from the UK Ministry of Defence Research Ethics Committee, and all protocols were conducted in accordance with the 2013 Declaration of Helsinki.

Study Design

This multi-center observational study recruited participants from 21 platoons (11 male platoons, 10 female platoons) commencing training from January 2014 to June 2016 across four seasons (19% winter, 20% spring, 29% summer and 32% autumn). Seasons were defined as winter (December-February), spring (March-May), summer (June-August), and autumn (September–November). All participants passed a physician-screened initial medical assessment before data collection. In week one of training, participants completed questionnaires on typical sleep duration and lifestyle factors. Height and body mass were measured in light clothing (with shoes removed) using a stadiometer and digital platform scale (SECA 703, Birmingham, UK), respectively. Body mass index (BMI; $kg \cdot m^{-2}$) was calculated from height and body mass. Incidence of physician-diagnosed URTI was retrieved from the participant's Army medical records for the 13-week period of training. For each URTI episode, the number of lost training days due to URTI was recorded. At the end of training, participants repeated the sleep questionnaire to retrospectively report typical sleep duration over the 13 weeks of training.

Questionnaires

To assess sleep duration, a questionnaire was developed by the study team based on the procedures of Prather & Cohen.[8] At the start of training, participants were asked to report the time they went to sleep and awoke on a typical night before training started. In the final week of training, participants were then asked to retrospectively report the typical time they went to sleep and awoke during training. Participants completed a lifestyle questionnaire to assess their alcohol consumption and cigarette smoking. This questionnaire was tested internally by Army

Recruitment and Training Division for comprehension and repeatability, with a test-retest intraclass correlation coefficient >0.76 and percentage agreement >93%.

Statistical Analysis

All analyses were performed using SPSS 22.0 (IBM, Armonk, New York, USA). Sleep duration prior to and during initial military training was categorized as <6 hours, 6-7 hours, 7-9 hours, and >9 hours according to the categories defined in sleep recommendation position statements.[1,2] Since very few participants slept more than 9 hours per night during training (n = 10; 2%), 7-9 hours and >9 hours per night were collapsed for some analyses. A binary logistic regression model was computed to predict URTI risk based on sleep duration during initial military training after controlling for sex, BMI, alcohol, smoking and season of recruitment. Chi-square was computed to detect differences between categorical variables. Independent or Paired Student T-test was used to detect significant differences between continuous variables. A P value <0.05 indicated statistical significance.

RESULTS

Reported night time sleep duration before and during Army training

Prior to joining the Army, 57% of participants reported meeting sleep recommendations of 7-9 hours per night (Figure 1).[1,2] At the end of training, participants who reported meeting sleep recommendations during the previous 13 weeks increased to 60% but only because participants reporting more than 9 hours of sleep per night decreased during training (from 30% to 2%). Overall, participants who reported sleeping less than 7 hours per night increased from 13% before training to 38% during training (X^2 = 3.8; P = 0.05). Self-reported sleep duration

decreased from before to during training, falling to the lower end of professional recommendations (8.5 ± 1.6 hours before to 7.0 ± 0.8 hours during; $P < 0.01$). Female participants reported greater mean sleep duration than male participants prior to and during training (females 8.7 ± 1.4 hours pre-training *vs.* 7.2 ± 0.9 hours during training; males 8.4 ± 1.7 hours pre-training *vs.* 6.9 ± 0.7 hours during training; $P < 0.01$).

Reported nighttime sleep influence on URTI and lost training days

Overall, 49 participants (8%) were diagnosed by a physician with at least one URTI, and 3 participants (<1%) were diagnosed with two URTI's during their 13 week training course. Episodes of URTI were distributed across training with 50% occurring in the first six weeks, 19% of which occurred in the first two weeks. In a logistic regression model, participants who reported sleeping less than 6 hours per night were four times more likely to be diagnosed with URTI compared with participants who slept 7−9 hours per night after controlling for sex, BMI, season of recruitment, smoking, and alcohol (OR 4.4; 95% CI, 1.5–12.9, P <0.01). Figure 2 shows that 21% of participants who slept less than 6 hours were diagnosed with at least one URTI compared with 7% URTI incidence in participants who slept 6 to 9 hours ($P = 0.02$). URTI's diagnosed in participants who slept less than 6 hours were reported in both sexes and spread across five platoons and all four seasons. The majority ($n = 26$; 53%) of participants who contracted a URTI started initial military training in the autumn, the UK common cold season.[9] Particularly noteworthy was that of those who started training in the autumn, 40% of participants who reported sleeping less than 6 hours per night were diagnosed with URTI, while 13% of participants who reported sleeping 7-9 hours per night were diagnosed with URTI ($X^2 = 9.0$; $P = 0.03$). Each URTI resulted in 2.9 ± 1.5 lost training days. Participants who were diagnosed with a

URTI had more total lost training days for any illness compared with participants who did not contract a URTI during initial military training (3.3 ± 1.9 *vs*. 0.4 ± 1.3; $P < 0.01$; Figure 3).

DISCUSSION

The aim of this study was to describe self-reported sleep duration in a large cohort of male and female military recruits during 13 weeks of initial military training and to assess the relationship between reported sleep duration and incidence of URTI's. Of the 651 participants in this study, 38% reported sleeping less than 7 hours per night during Army training, increasing from 13% before the start of training (Figure 1). While inadequate sleep duration has been associated with poor general health and decreased immunity,[2] this study expands the literature by showing that reported sleep duration during training is predictive of URTI diagnosis in military recruits, particularly in the common cold season. After controlling for sex, BMI, season of recruitment, smoking, and alcohol, participants who slept less than 6 hours per night during training were approximately four times more likely to be diagnosed by a physician with an URTI compared with participants who met the 7−9 hours per night sleep recommendations (Figure 2).[1,2] Each URTI resulted in approximately three lost training days, causing ill participants to miss more total training (Figure 3). Our findings support behaviors promoted in the US military performance triad, a scheme that emphasizes sleep, along with nutrition and physical activity, to improve health and readiness of its force.[10] The link between sleep, illness, and ability to train has widespread implications for military training. Thus, teaching sleep hygiene to recruits early in their career may reduce rates of sleep disorders in otherwise healthy young men and women training to become soldiers.

We showed a high prevalence of inadequate self-reported sleep duration in military training, with 38% of military recruits reporting sleeping less than the recommended minimum of 7 hours per night during Army training. Previous research in a sample of 66 U.S. Army recruits found that self-reported mean nighttime sleep duration decreased from 8-9 hours before basic training to 5-6 hours during the first four weeks of training, although the distribution of recruits in each category of sleep duration was not provided.[3] Comparably, participants in our study reported mean nighttime sleep duration of approximately 7 hours, 1.5 fewer hours per night during training compared to their civilian schedule, but our sample was larger, conducted at two UK military locations, and covered a longer period of training (13 weeks vs. 4 weeks). Male and female recruits completed Army training at separate military units commanded by different military staff and schedules, which may explain why female participants reported greater sleep duration than male participants during training (7.2 ± 0.9 *vs*. 6.9 ± 0.7 hours). Interestingly, female participants also had greater sleep duration prior to military training, but the reasons for this were not explored. Previous mixed-sex studies have not compared sleep duration between male and female military personnel.[3,11,12]

Other large studies describing long-term sleep duration in military personnel have been conducted in deployed units, when soldiers tend to experience frequent sleep restrictions.[11,12,13] Deployed U.S. Naval personnel self-reported an average of 5.9 hours per night, and those who slept less than 6 hours had more mission-related accidents compared to those who slept greater than 7 hours.[13] In a database of U.S. personnel across military branches, self-reported sleep duration was significantly shorter in deployment compared to pre-deployment, although mean sleep duration for both time periods was less than the 7 hours per night recommended by

196 experts.[11] Advanced military training may require periods of sleep restriction that defy
197 recommendations for the purpose of simulated combat exercise.[14] Thus, exposing recruits to
198 some level of sleep restriction in basic training may prepare them for deployment, but chronic
199 sleep restriction appears to have negative effects on health. It has been shown that athletes need
200 more sleep than non-athletes to assist with recovery from strenuous exercise,[15] and the physical
201 demands of initial military training may stress recruits in a similar manner to athletic training.
202 Sleeping one additional hour per night for six consecutive nights preceding sleep deprivation has
203 been shown to improve motor performance and reduce perceived exertion, supporting a benefit
204 of sleep extension on physical performance.[16] A small percentage of participants (2%) in our
205 study reported exceeding 9 hours per night during training, which may be acceptable and could
206 even be beneficial during training since current evidence does not link longer sleep duration to
207 poorer health in young adults aged 20-39 years.[2]
208
209 The chronic reduction in sleep duration observed in military training may elicit a state of stress,
210 in-turn suppressing immunity to infection.[17] We show that participants who did not meet sleep
211 recommendations suffered a greater incidence of URTI and missed more training than
212 participants who met sleep recommendations. Our data support findings from a healthy civilian
213 population showing that those who slept less than 6 hours per night had approximately four-fold
214 greater risk of developing a common cold (in a live common cold challenge model) compared to
215 those who slept at 7-9 hours per night.[4] Recruits generally have a higher risk for URTI compared
216 to civilians and trained service personnel because men and women come together from all over
217 the country, carrying different strains of infection into a shared living environment and
218 undertaking a challenging physical training schedule.[7] However, the incidence of URTI in this

sample was lower than normally reported, considering an individual typically contracts 2-4 respiratory infections per year[6] and only 8% of participants in our study were diagnosed by a physician with an URTI. The low incidence may be explained by URTI confirmation with physician diagnosis, which likely missed more minor illnesses that did not warrant a medical visit, particularly in the resilient Armed forces culture. Reporting daily common cold symptoms with a tool such as the Jackson Common Cold Questionnaire[18] would likely capture missed URTI episodes to represent true incidence and the effect on training. For instance, 46% of Olympic athletes who self-reported illness logged symptoms of URTI during autumn in Australia (April-May), and each episode resulted in approximately four days of lost training.[19] However, no link was identified between illness and self-reported sleep duration in those athletes. Our study showed a significant influence of sleep on URTI during the common cold season: participants who reported sleeping less than 6 hours per night during training had higher physician diagnosed URTI incidence in the common cold season than participants who reported sleeping 7-9 hours per night (40% *vs*. 13%). URTI's are responsible for 12,000-27,000 lost training days per year in the US military, highlighting the burden of this illness.[7] We showed that each URTI incidence requiring a visit to a physician decreased training by approximately three days, and participants with URTI lost more total training time.

A limitation of this study was that sleep duration was self-reported and recalled retrospectively, although reporting bias is less likely in healthy participants than those with sleep or psychiatric disorder.[20] British military recruits are medically screened for sleep and psychiatric disorders that incompatible with military training. Furthermore, recruits follow a rigid training schedule that likely assists with accurate reporting. However, there may be differences across the weeks of

training, with limited or interrupted sleep in the first four to six weeks, followed by greater sleep duration once a routine is established. Therefore, a daily or weekly self-reported sleep diary would be a practical method to capture variations in sleep duration across training. Alternatively, actigraphy would provide more accurate characterization of sleep duration but may present practical and cost challenges in a large sample size. Each URTI episode was diagnosed by a physician but was not verified by virology. Future studies should use Jackson Common Cold Questionnaire to screen for symptoms and confirm URTI with pathological analysis of nasopharyngeal and throat swabs, the current gold standard.[21] Additionally, expanding outcomes to physical and cognitive performance may highlight other important functions of sleep. Strengths of this study include a large sample of healthy men and women from two military training units. We also recruited participants throughout the year to account for high and low seasons for URTI incidence. Although sleep duration data during training were collected retrospectively, it was representative of typical sleep-wake behavior, rather than 1-2 day periods of sleep deprivation.

Practical applications of this research are to educate military training staff and recruits on optimal sleep duration for health and performance as well as recognizing how URTI is associated with short sleep duration and lost training to help to discourage chronic sleep restriction of recruits during initial training. Whenever possible, it is recommended that military commanders and training staff encourage a minimum of 7 hours of consecutive sleep per night to reduce risk of URTI and prevent recruits from missing training. Additional established benefits of meeting sleep recommendations include improved training recovery, reaction time, concentration and memory.[22] Nevertheless, sleep restriction is part of military operations and may be essential to

elements of military training. Consideration should be given to the amount of sleep soldiers get during deployments to maintain the effectiveness of the deployed force, which is prone to outbreaks of URTI.[23,24,25] Evidence suggests that individuals feel less tired and stressed following consecutive nights of sleep restriction, showing perceived mental habituation to sleep deficits, yet disruptions to the hypothalamus-pituitary-adrenal axis and inflammatory response, with likely negative consequences for immunity, are still observed.[26] Because physiological consequences persist in spite of mental resilience, training staff and recruits should consider measures to improve sleep duration during initial military training as they transition from civilian life. Recruits may benefit from longer sleep duration opportunities at the start of training and then progress to reduced nighttime sleep as weeks continue, similar to physical training progression. Daytime naps between 10-30 minutes could also be beneficial to complement nighttime sleep duration.[27] Other strategies include limiting light, noise, caffeine, and use of electronic devices prior to bedtime.[22] Since recruits experienced decreased sleep duration compared with civilian life, the military may consider screening them to identify the cause of reduced sleep duration, such as internal sleep disruptions or external military training schedule. Internal disruptions related to mental health, notably stress and depression, have well-known influences on sleep duration and quality,[2] and chronic sleep restriction in service personnel reduces resilience to depression and posttraumatic stress disorder.[22] Creating a homogenous living arrangement to stratify recruits into groups with similar sleep-wake cycles would encourage recruits to meet sleep recommendations.

In conclusion, these findings show that 38% of male and female British military recruits fail to achieve minimum sleep duration recommendations of 7 hours per night during 13 weeks of

training. Participants who reported sleeping less than 6 hours per night were four times more likely to be diagnosed with URTI than participants who reported sleeping 7-9 hours per night. Diagnosis with a URTI impacts military readiness, as ill participants missed significantly more training time. Practical recommendations are to encourage, when possible, 7 or more hours of sleep per night to reduce risk of URTI, prevent recruits from missing training, and improve overall health and morale. Since elements of military training necessitate sleep restriction, future studies should examine interventions to reduce the negative effects on immunity that lead to greater incidence of URTI and the impact on physical and cognitive performance.

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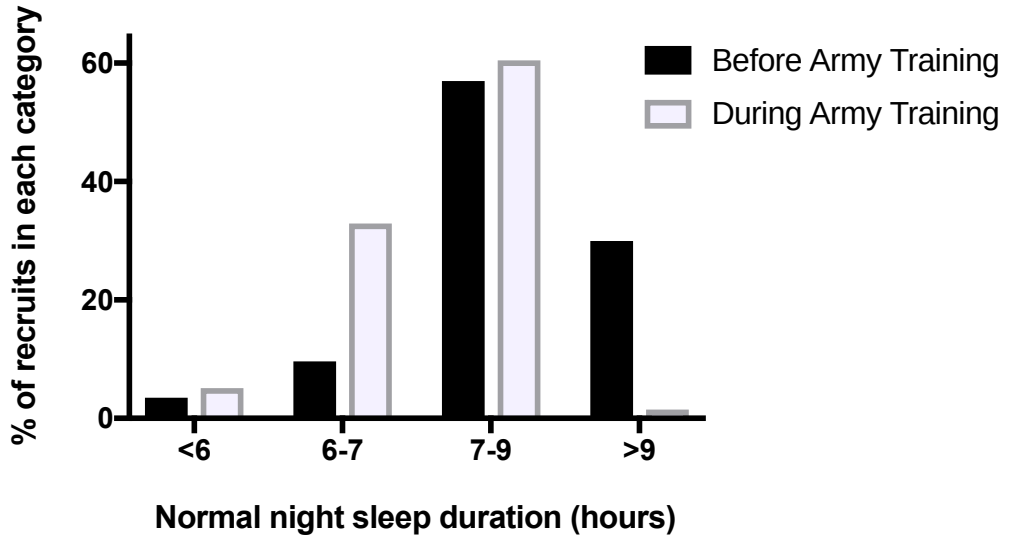
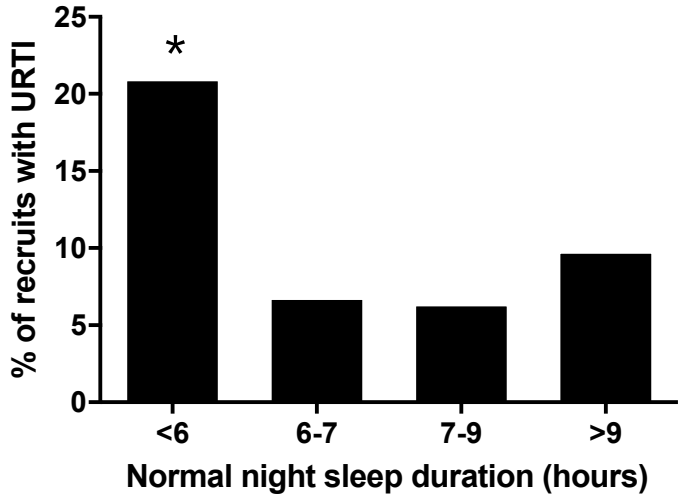
FIGURES

Figure 1. Self-reported sleep duration in 651 recruits before and during initial military training.



366 **Figure 2.** Military recruits who reported sleeping less than 6 hours per night had higher
367 incidence of physician-diagnosed upper respiratory tract infection (URTI) than recruits sleeping
368 6-9 hours. *significantly greater than 6-7 hours and 7-9 hours (P = 0.02).



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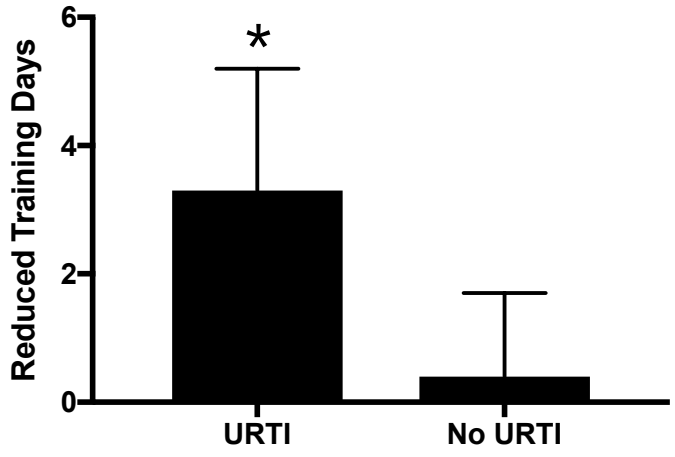
373 **Figure 3.** Recruits diagnosed with URTI had more lost training days for any illness than recruits

374 not diagnosed with URTI (*$P < 0.01$). Data are presented as mean ± SD.



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