



## Increased Risk of Upper Respiratory Infection in Military Recruits Who Report Sleeping Less Than 6 h per night

Wentz, Laurel M; Ward, Mark D; Potter, Claire; Oliver, Samuel J; Jackson, Sarah; Izard, Rachel M; Greeves, Julie P; Walsh, Neil P

### Military Medicine

DOI:  
[10.1093/milmed/usy090](https://doi.org/10.1093/milmed/usy090)

Published: 01/11/2018

Peer reviewed version

[Cyswllt i'r cyhoeddiad / Link to publication](#)

*Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):*  
Wentz, L. M., Ward, M. D., Potter, C., Oliver, S. J., Jackson, S., Izard, R. M., Greeves, J. P., & Walsh, N. P. (2018). Increased Risk of Upper Respiratory Infection in Military Recruits Who Report Sleeping Less Than 6 h per night. *Military Medicine*, 183(11-12), e699–e704.  
<https://doi.org/10.1093/milmed/usy090>

#### Hawliau Cyffredinol / General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

#### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Pages: 18  
Words: 3273  
Tables: 0  
Figures: 3  
References: 27  
Contact: Professor Neil P. Walsh, PhD  
Email: [n.walsh@bangor.ac.uk](mailto:n.walsh@bangor.ac.uk)  
Guarantor: Professor Neil P. Walsh, PhD

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

Laurel M. Wentz, PhD, RD<sup>1</sup>

Mark D. Ward, MSc<sup>2</sup>

Claire Potter, MSc<sup>2</sup>

Samuel J. Oliver, PhD<sup>2</sup>

Lt Col Sarah Jackson, MD<sup>3</sup>

Rachel M. Izard, PhD<sup>4</sup>

Julie P. Greeves, PhD<sup>3</sup>

Neil P. Walsh, PhD<sup>2</sup>.

<sup>1</sup>Beaver College of Health Sciences, 261 Locust Street, Appalachian State University, Boone, NC, 28608, USA

<sup>2</sup>College of Health and Behavioural Sciences, Holyhead Road, Bangor University, Bangor, Gwynedd, LL57 2PZ, UK

<sup>3</sup>Army Personnel and Research Capability, Army HQ, Marlborough Lines, Andover, Hampshire, SP11 8HT UK

<sup>4</sup>Occupational Medicine, HQ Army Recruiting and Training Division, Trenchard Lines, Upavon,  
Wiltshire, SN9 6BE, UK

Funding/COI: This work was funded by the Ministry of Defence (Army), UK.

Acknowledgements: We would like to thank Xin Hui Aw Yong, Daniel Kashi and Alex Carswell for their assistance with data collection.

Poster presented at American College of Sports Medicine Annual Conference, Denver, CO, USA, 1 JUNE 2017.

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

1 **ABSTRACT**

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

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

35

36

37

38 **INTRODUCTION**

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

60

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

72

## 73 **MATERIALS AND METHODS**

### 74 **Participants**

75 Participants were 651 British Army recruits aged  $22 \pm 3$  years who completed 13 weeks of basic  
76 military training. Male recruits ( $n = 438$ ; body mass  $76.1 \pm 10.0$  kg; height  $1.77 \pm 0.06$  m; BMI  
77  $24.2 \pm 2.7$  kg·m<sup>-2</sup>) completed the Combat Infantryman's Course (Line Infantry) at the Infantry  
78 Training Centre Catterick, UK. Female recruits ( $n = 213$ ; body mass  $65.1 \pm 8.4$  kg; height  $1.66 \pm$   
79  $0.06$  m; BMI  $23.7 \pm 2.5$  kg·m<sup>-2</sup>) completed the Common Military Syllabus for Standard Entry  
80 Recruits at the Army Training Centre Pirbright, UK. Study participants provided fully informed  
81 written consent in the first week of training. Ethical approval was obtained from the UK Ministry  
82 of Defence Research Ethics Committee, and all protocols were conducted in accordance with the  
83 2013 Declaration of Helsinki.

## 84 **Study Design**

85 This multi-center observational study recruited participants from 21 platoons (11 male platoons,  
86 10 female platoons) commencing training from January 2014 to June 2016 across four seasons  
87 (19% winter, 20% spring, 29% summer and 32% autumn). Seasons were defined as winter  
88 (December-February), spring (March-May), summer (June-August), and autumn (September–  
89 November). All participants passed a physician-screened initial medical assessment before data  
90 collection. In week one of training, participants completed questionnaires on typical sleep  
91 duration and lifestyle factors. Height and body mass were measured in light clothing (with shoes  
92 removed) using a stadiometer and digital platform scale (SECA 703, Birmingham, UK),  
93 respectively. Body mass index (BMI;  $\text{kg}\cdot\text{m}^{-2}$ ) was calculated from height and body mass.  
94 Incidence of physician-diagnosed URTI was retrieved from the participant's Army medical  
95 records for the 13-week period of training. For each URTI episode, the number of lost training  
96 days due to URTI was recorded. At the end of training, participants repeated the sleep  
97 questionnaire to retrospectively report typical sleep duration over the 13 weeks of training.

98

## 99 **Questionnaires**

100 To assess sleep duration, a questionnaire was developed by the study team based on the  
101 procedures of Prather & Cohen,<sup>8</sup> who showed that participants' self-reported sleep duration  
102 predicted their antibody response to vaccination. Following their model, participants in our study  
103 were asked to report the time they went to sleep and awoke on a typical night before training  
104 started. In the final week of training, participants were then asked to retrospectively report the  
105 typical time they went to sleep and awoke during training. Sleep duration was calculated as the  
106 number of hours and minutes elapsed between the time they reported going to sleep and the time



107 they reported waking. Participants completed a lifestyle questionnaire to assess their alcohol  
108 consumption and cigarette smoking. This questionnaire was tested internally by Army  
109 Recruitment and Training Division for comprehension and repeatability, with a test-retest  
110 intraclass correlation coefficient >0.76 and percentage agreement >93%.

111

## 112 **Statistical Analysis**

113 All analyses were performed using SPSS 22.0 (IBM, Armonk, New York, USA). Sleep duration  
114 prior to and during initial military training was categorized as <6 hours, 6 to <7 hours, 7 to 9  
115 hours, and >9 hours according to the categories defined in sleep recommendation position  
116 statements.<sup>1,2</sup> Since very few participants slept more than 9 hours per night during training ( $n =$   
117 10; 2%), 7-9 hours and >9 hours per night were collapsed for some analyses. A binary logistic  
118 regression model was computed to predict URTI risk based on sleep duration during initial  
119 military training after controlling for sex, BMI, alcohol, smoking and season of recruitment. Chi-  
120 square was computed to detect differences between categorical variables. Independent or Paired  
121 Student T-test was used to detect significant differences between continuous variables. A  $P$  value  
122 <0.05 indicated statistical significance.

123

## 124 **RESULTS**

### 125 **Reported night time sleep duration before and during Army training**

126 Prior to joining the Army, 57% of participants reported meeting sleep recommendations of 7-9  
127 hours per night (Figure 1).<sup>1,2</sup> At the end of training, participants who reported meeting sleep  
128 recommendations during the previous 13 weeks increased to 60% but only because participants  
129 reporting more than 9 hours of sleep per night decreased during training (from 30% to 2%).

130 Overall, participants who reported sleeping less than 7 hours per night increased from 13%  
131 before training to 38% during training ( $X^2 = 3.8$ ;  $P = 0.05$ ). Self-reported sleep duration  
132 decreased from before to during training, falling to the lower end of professional  
133 recommendations ( $8.5 \pm 1.6$  hours before to  $7.0 \pm 0.8$  hours during;  $P < 0.01$ ). Female  
134 participants reported greater mean sleep duration than male participants prior to and during  
135 training (females  $8.7 \pm 1.4$  hours pre-training vs.  $7.2 \pm 0.9$  hours during training; males  $8.4 \pm 1.7$   
136 hours pre-training vs.  $6.9 \pm 0.7$  hours during training;  $P < 0.01$ ).

137

### 138 **Reported nighttime sleep influence on URTI and lost training days**

139 Overall, 49 participants (8%) were diagnosed by a physician with at least one URTI, and 3  
140 participants (<1%) were diagnosed with two URTI's during their 13 week training course.  
141 Episodes of URTI were distributed across training with 50% occurring in the first six weeks,  
142 19% of which occurred in the first two weeks. In a logistic regression model, participants who  
143 reported sleeping less than 6 hours per night were four times more likely to be diagnosed with  
144 URTI compared with participants who slept 7–9 hours per night after controlling for sex, BMI,  
145 season of recruitment, smoking, and alcohol (OR 4.4; 95% CI, 1.5–12.9,  $P < 0.01$ ). Figure 2  
146 shows that 21% of participants who slept less than 6 hours were diagnosed with at least one  
147 URTI compared with 7% URTI incidence in participants who slept 6 to 9 hours ( $P = 0.02$ ).  
148 URTI's diagnosed in participants who slept less than 6 hours were reported in both sexes and  
149 spread across five platoons and all four seasons. The majority ( $n = 26$ ; 53%) of participants who  
150 contracted a URTI started initial military training in the autumn, the UK common cold season.<sup>9</sup>  
151 Particularly noteworthy was that of those who started training in the autumn, 40% of participants  
152 who reported sleeping less than 6 hours per night were diagnosed with URTI, while 13% of

153 participants who reported sleeping 7-9 hours per night were diagnosed with URTI ( $X^2 = 9.0$ ;  $P =$   
154  $0.03$ ). Each URTI resulted in  $2.9 \pm 1.5$  lost training days. Participants who were diagnosed with a  
155 URTI had more total lost training days for any illness compared with participants who did not  
156 contract a URTI during initial military training ( $3.3 \pm 1.9$  vs.  $0.4 \pm 1.3$ ;  $P < 0.01$ ; Figure 3).

157

## 158 **DISCUSSION**

159 The aim of this study was to describe self-reported sleep duration in a large cohort of male and  
160 female military recruits during 13 weeks of initial military training and to assess the relationship  
161 between reported sleep duration and incidence of URTI's. Of the 651 participants in this study,  
162 38% reported sleeping less than 7 hours per night during Army training, increasing from 13%  
163 before the start of training (Figure 1). While inadequate sleep duration has been associated with  
164 poor general health and decreased immunity,<sup>2</sup> this study expands the literature by showing that  
165 reported sleep duration during training is predictive of URTI diagnosis in military recruits,  
166 particularly in the common cold season. After controlling for sex, BMI, season of recruitment,  
167 smoking, and alcohol, participants who slept less than 6 hours per night during training were  
168 approximately four times more likely to be diagnosed by a physician with an URTI compared  
169 with participants who met the 7–9 hours per night sleep recommendations (Figure 2).<sup>1,2</sup> Each  
170 URTI resulted in approximately three lost training days, causing ill participants to miss more  
171 total training (Figure 3). Our findings support behaviors promoted in the US military  
172 performance triad, a scheme that emphasizes sleep, along with nutrition and physical activity, to  
173 improve health and readiness of its force.<sup>10</sup> The link between sleep, illness, and ability to train  
174 has widespread implications for military training. Thus, teaching sleep hygiene to recruits early

175 in their career may reduce rates of sleep disorders in otherwise healthy young men and women  
176 training to become soldiers.

177

178 We showed a high prevalence of inadequate self-reported sleep duration in military training, with  
179 38% of military recruits reporting sleeping less than the recommended minimum of 7 hours per  
180 night during Army training. Previous research in a sample of 66 U.S. Army recruits found that  
181 self-reported mean nighttime sleep duration decreased from 8-9 hours before basic training to 5-  
182 6 hours during the first four weeks of training, although the distribution of recruits in each  
183 category of sleep duration was not provided.<sup>3</sup> Comparably, participants in our study reported  
184 mean nighttime sleep duration of approximately 7 hours, 1.5 fewer hours per night during  
185 training compared to their civilian schedule, but our sample was larger, conducted at two UK  
186 military locations, and covered a longer period of training (13 weeks vs. 4 weeks). Male and  
187 female recruits completed Army training at separate military units commanded by different  
188 military staff and schedules, which may explain why female participants reported greater sleep  
189 duration than male participants during training ( $7.2 \pm 0.9$  vs.  $6.9 \pm 0.7$  hours). Interestingly,  
190 female participants also had greater sleep duration prior to military training, but the reasons for  
191 this were not explored. Previous mixed-sex studies have not compared sleep duration between  
192 male and female military personnel.<sup>3,11,12</sup>

193

194 Other large studies describing long-term sleep duration in military personnel have been  
195 conducted in deployed units, when soldiers tend to experience frequent sleep restrictions.<sup>11,12,13</sup>  
196 Deployed U.S. Naval personnel self-reported an average of 5.9 hours per night, and those who  
197 slept less than 6 hours had more mission-related accidents compared to those who slept greater

198 than 7 hours.<sup>13</sup> In a database of U.S. personnel across military branches, self-reported sleep  
199 duration was significantly shorter in deployment compared to pre-deployment, although mean  
200 sleep duration for both time periods was less than the 7 hours per night recommended by  
201 experts.<sup>11</sup> Advanced military training may require periods of sleep restriction that defy  
202 recommendations for the purpose of simulated combat exercise.<sup>14</sup> Thus, exposing recruits to  
203 some level of sleep restriction in basic training may prepare them for deployment, but chronic  
204 sleep restriction appears to have negative effects on health. It has been shown that athletes need  
205 more sleep than non-athletes to assist with recovery from strenuous exercise,<sup>15</sup> and the physical  
206 demands of initial military training may stress recruits in a similar manner to athletic training.  
207 Sleeping one additional hour per night for six consecutive nights preceding sleep deprivation has  
208 been shown to improve motor performance and reduce perceived exertion, supporting a benefit  
209 of sleep extension on physical performance.<sup>16</sup> A small percentage of participants (2%) in our  
210 study reported exceeding 9 hours per night during training, which may be acceptable and could  
211 even be beneficial during training since current evidence does not link longer sleep duration to  
212 poorer health in young adults aged 20-39 years.<sup>2</sup>

213

214 The chronic reduction in sleep duration observed in military training may elicit a state of stress,  
215 in-turn suppressing immunity to infection.<sup>17</sup> We show that participants who did not meet sleep  
216 recommendations suffered a greater incidence of URTI and missed more training than  
217 participants who met sleep recommendations. Our data support findings from a healthy civilian  
218 population showing that those who slept less than 6 hours per night had approximately four-fold  
219 greater risk of developing a common cold (in a live common cold challenge model) compared to  
220 those who slept at 7-9 hours per night.<sup>4</sup> Recruits generally have a higher risk for URTI compared

221 to civilians and trained service personnel because men and women come together from all over  
222 the country, carrying different strains of infection into a shared living environment and  
223 undertaking a challenging physical training schedule.<sup>7</sup> However, the incidence of URTI in this  
224 sample was lower than normally reported, considering an individual typically contracts 2-4  
225 respiratory infections per year<sup>6</sup> and only 8% of participants in our study were diagnosed by a  
226 physician with an URTI. The low incidence may be explained by URTI confirmation with  
227 physician diagnosis, which likely missed more minor illnesses that did not warrant a medical  
228 visit, particularly in the resilient Armed forces culture. Reporting daily common cold symptoms  
229 with a tool such as the Jackson Common Cold Questionnaire<sup>18</sup> would likely capture missed  
230 URTI episodes to represent true incidence and the effect on training. For instance, 46% of  
231 Olympic athletes who self-reported illness logged symptoms of URTI during autumn in Australia  
232 (April-May), and each episode resulted in approximately four days of lost training.<sup>19</sup> However,  
233 no link was identified between illness and self-reported sleep duration in those athletes. Our  
234 study showed a significant influence of sleep on URTI during the common cold season:  
235 participants who reported sleeping less than 6 hours per night during training had higher  
236 physician diagnosed URTI incidence in the common cold season than participants who reported  
237 sleeping 7-9 hours per night (40% vs. 13%). URTI's are responsible for 12,000-27,000 lost  
238 training days per year in the US military, highlighting the burden of this illness.<sup>7</sup> We showed that  
239 each URTI incidence requiring a visit to a physician decreased training by approximately three  
240 days, and participants with URTI lost more total training time.

241

242 A limitation of this study was that sleep duration was self-reported and recalled retrospectively,  
243 although reporting bias is less likely in healthy participants than those with sleep or psychiatric

244 disorder.<sup>20</sup> British military recruits are medically screened for sleep and psychiatric disorders that  
245 are incompatible with military training. Recruits follow a rigid training schedule that likely  
246 assists with accurate reporting, yet co-habitation of military recruits in close quarters increases  
247 risk of pathogen infection and is a possible confounder to findings. There may be differences  
248 across the weeks of training, with limited or interrupted sleep in the first four to six weeks,  
249 followed by greater sleep duration once a routine is established. Therefore, a daily or weekly  
250 self-reported sleep diary would be a practical method to capture variations in sleep duration  
251 across training. Alternatively, actigraphy would provide more accurate characterization of sleep  
252 duration but may present practical and cost challenges in a large sample size. Each URTI episode  
253 was diagnosed by a physician but was not verified by virology. Future studies should use  
254 Jackson Common Cold Questionnaire to screen for symptoms and confirm URTI with  
255 pathological analysis of nasopharyngeal and throat swabs, the current gold standard.<sup>21</sup>  
256 Additionally, expanding outcomes to physical and cognitive performance may highlight other  
257 important functions of sleep. Strengths of this study include a large sample of healthy men and  
258 women from two military training units. We also recruited participants throughout the year to  
259 account for high and low seasons for URTI incidence. Although sleep duration data during  
260 training were collected retrospectively, it was representative of typical sleep-wake behavior,  
261 rather than 1-2 day periods of sleep deprivation.

262

263 Practical applications of this research are to educate military training staff and recruits on  
264 optimal sleep duration for health and performance as well as recognizing how URTI is associated  
265 with short sleep duration and lost training to help to discourage chronic sleep restriction of  
266 recruits during initial training. Whenever possible, it is recommended that military commanders

267 and training staff encourage a minimum of 7 hours of consecutive sleep per night to reduce risk  
268 of URTI and prevent recruits from missing training. Additional established benefits of meeting  
269 sleep recommendations include improved training recovery, reaction time, concentration and  
270 memory.<sup>22</sup> Nevertheless, sleep restriction is part of military operations and may be essential to  
271 elements of military training. Consideration should be given to the amount of sleep soldiers get  
272 during deployments to maintain the effectiveness of the deployed force, which is prone to  
273 outbreaks of URTI.<sup>23,24,25</sup> Evidence suggests that individuals feel less tired and stressed  
274 following consecutive nights of sleep restriction, showing perceived mental habituation to sleep  
275 deficits, yet disruptions to the hypothalamus-pituitary-adrenal axis and inflammatory response,  
276 with likely negative consequences for immunity, are still observed.<sup>26</sup> Because physiological  
277 consequences persist in spite of mental resilience, training staff and recruits should consider  
278 measures to improve sleep duration during initial military training as they transition from civilian  
279 life. Recruits may benefit from longer sleep duration opportunities at the start of training and  
280 then progress to reduced nighttime sleep as weeks continue, similar to physical training  
281 progression. Daytime naps between 10-30 minutes could also be beneficial to complement  
282 nighttime sleep duration.<sup>27</sup> Other strategies include limiting light, noise, caffeine, and use of  
283 electronic devices prior to bedtime.<sup>22</sup> Since recruits experienced decreased sleep duration  
284 compared with civilian life, the military may consider screening them to identify the cause of  
285 reduced sleep duration, such as internal sleep disruptions or external military training schedule.  
286 Internal disruptions related to mental health, notably stress and depression, have well-known  
287 influences on sleep duration and quality,<sup>2</sup> and chronic sleep restriction in service personnel  
288 reduces resilience to depression and posttraumatic stress disorder.<sup>22</sup> Creating a homogenous



289 living arrangement to stratify recruits into groups with similar sleep-wake cycles would  
290 encourage recruits to meet sleep recommendations.

291

292 In conclusion, these findings show that 38% of male and female British military recruits fail to  
293 achieve minimum sleep duration recommendations of 7 hours per night during 13 weeks of  
294 training. Participants who reported sleeping less than 6 hours per night were four times more  
295 likely to be diagnosed with URTI than participants who reported sleeping 7-9 hours per night.  
296 Diagnosis with a URTI impacts military readiness, as ill participants missed significantly more  
297 training time. Practical recommendations are to encourage, when possible, 7 or more hours of  
298 sleep per night to reduce risk of URTI, prevent recruits from missing training, and improve  
299 overall health and morale. Since elements of military training necessitate sleep restriction, future  
300 studies should examine interventions to reduce the negative effects on immunity that lead to  
301 greater incidence of URTI and the impact on physical and cognitive performance.

302

303

304 **REFERENCES**

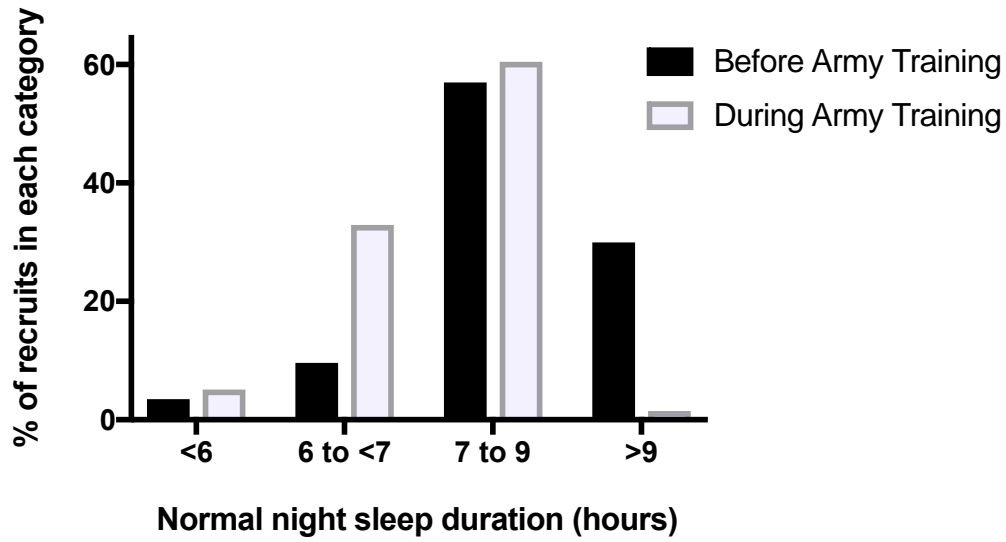
- 305 1. Hirshkowitz M, Whiton K, Albert SM, *et al.*: National Sleep Foundation’s sleep time duration  
306 recommendations: methodology and results summary. *Sleep Health* 1(1): 40-43.
- 307 2. Watson NF, Badr MS, Belenky G, *et al.*: Joint Consensus Statement of the American  
308 Academy of Sleep Medicine and Sleep Research Society on the Recommended Amount of Sleep  
309 for a Healthy Adult: Methodology and Discussion. *Sleep* 2015, 38(8): 1161-1183.
- 310 3. Crowley SK, Wilkinson LL, Burroughs EL, *et al.*: Sleep during basic combat training: a  
311 qualitative study. *Mil Med* 2012, 177(7): 823-828.
- 312 4. Prather AA, Janicki-Deverts D, Hall MH, *et al.*: Behaviorally Assessed Sleep and  
313 Susceptibility to the Common Cold. *Sleep* 2015, 38(9): 1353-1359.
- 314 5. Peake JM, Neubauer O, Walsh NP, *et al.*: Recovery of the immune system after exercise. *J*  
315 *Appl Physiol* 2017, 122(5): 1077-1087.
- 316 6. Garibaldi RA: Epidemiology of community-acquired respiratory tract infections in adults.  
317 Incidence, etiology, and impact. *Am J Med* 1985, 78(6B): 32-37.
- 318 7. Sanchez JL, Cooper MJ, Myers CA, *et al.*: Respiratory Infections in the U.S. Military: Recent  
319 Experience and Control. *Clin Microbiol Rev* 2015, 28(3): 743-800.
- 320 8. Prather AA, Hall M, Fury JM, *et al.*: Sleep and antibody response to hepatitis B vaccination.  
321 *Sleep* 2012, 35(8): 1063-1069.
- 322 9. Hanstock HG, Walsh NP, Edwards JP, *et al.*: Tear Fluid SIgA as a Noninvasive Biomarker of  
323 Mucosal Immunity and Common Cold Risk. *Med Sci Sports Exerc* 2016, 48(3): 569-577.
- 324 10. Lentino CV, Purvis DL, Murphy KJ, *et al.*: Sleep as a component of the performance triad:  
325 the importance of sleep in a military population. *US Army Med Dep J* 2013: 98-108.

- 326 11. Seelig AD, Jacobson IG, Smith B, *et al.*: Sleep patterns before, during, and after deployment  
327 to Iraq and Afghanistan. *Sleep* 2010, 33(12): 1615-1622.
- 328 12. Taylor MK, Hilton SM, Campbell JS, *et al.*: Prevalence and mental health correlates of sleep  
329 disruption among military members serving in a combat zone. *Mil Med* 2014, 179(7): 744-751.
- 330 13. Harrison E, Glickman GL, Beckerley S, *et al.*: Self-Reported Sleep During U.S. Navy  
331 Operations and the Impact of Deployment-Related Factors. *Mil Med* 2017, 182(S1): 189-194.
- 332 14. Lieberman HR, Bathalon GP, Falco CM, *et al.*: Severe decrements in cognition function and  
333 mood induced by sleep loss, heat, dehydration, and undernutrition during simulated combat. *Biol*  
334 *Psychiatry* 2005, 57(4): 422-429.
- 335 15. Simpson NS, Gibbs EL, Matheson GO: Optimizing sleep to maximize performance:  
336 implications and recommendations for elite athletes. *Scand J Med Sci Sports* 2017, 27(3): 266-  
337 274.
- 338 16. Arnal PJ, Lapole T, Erblang M, *et al.*: Sleep Extension before Sleep Loss: Effects on  
339 Performance and Neuromuscular Function. *Med Sci Sports Exerc* 2016, 48(8): 1595-1603.
- 340 17. Besedovsky L, Lange T, Born J: Sleep and immune function. *Pflugers Arch* 2012, 463(1):  
341 121-137.
- 342 18. Jackson GG, Dowling HF, Spiesman IG, *et al.*: Transmission of the common cold to  
343 volunteers under controlled conditions. The common cold as a clinical entity. *AMA Arch Intern*  
344 *Med* 1958, 101(2): 267-278.
- 345 19. Drew M, Vlahovich N, Hughes D, *et al.*: Prevalence of illness, poor mental health and sleep  
346 quality and low energy availability prior to the 2016 Summer Olympic Games. *Br J Sports Med*  
347 2017, 52(1): 47-53.

- 348 20. Cohen S, Doyle WJ, Alper CM, *et al.*: Sleep habits and susceptibility to the common cold.  
349 Arch Intern Med 2009, 169(1): 62-67.
- 350 21. Walsh NP, Gleeson M, Shephard RJ, *et al.*: Position statement. Part one: Immune function  
351 and exercise. Exerc Immunol Rev 2011, 17: 6-63.
- 352 22. Yarnell AM, Deuster P: Sleep As A Strategy For Optimizing Performance. J Spec Oper Med  
353 2016, 16(1): 81-85.
- 354 23. Eick AA, Faix DJ, Tobler SK, *et al.*: Serosurvey of bacterial and viral respiratory pathogens  
355 among deployed U.S. service members. Am J Prev Med 2011, 41(6): 573-580.
- 356 24. Korzeniewski K, Nitsch-Osuch A, Konior M, *et al.*: Respiratory tract infections in the  
357 military environment. Respir Physiol Neurobiol 2015, 209: 76-80.
- 358 25. Murray CK, Horvath LL: An approach to prevention of infectious diseases during military  
359 deployments. Clin Infect Dis 2007, 44(3): 424-430.
- 360 26. Simpson NS, DiIombi M, Scott-Sutherland J, *et al.*: Repeating patterns of sleep restriction  
361 and recovery: Do we get used to it? Brain Behav Immun 2016, 58: 142-151.
- 362 27. Blanchfield AB, Lewis-Jones TM, Wignall JR, *et al.*: The influence of an afternoon nap on  
363 the endurance performance of trained runners. Eur J Sport Sci 2018, in press.
- 364

365 **FIGURES**

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

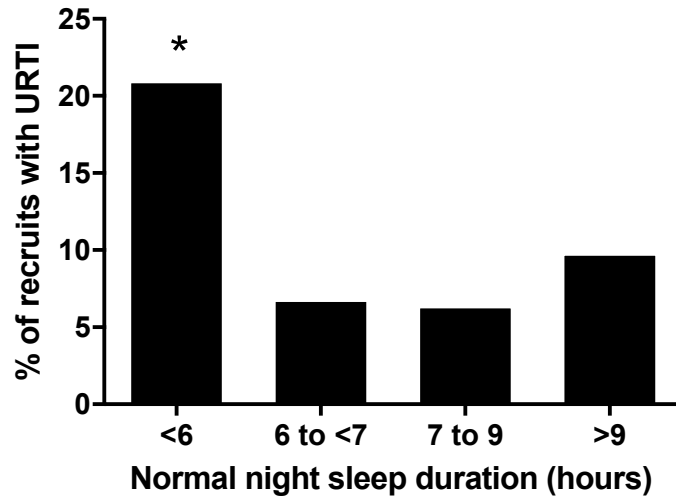


367

368

369

370 **Figure 2.** Military recruits who reported sleeping less than 6 hours per night had higher  
371 incidence of physician-diagnosed upper respiratory tract infection (URTI) than recruits sleeping  
372 6 to 9 hours. \*significantly greater than 6 to <7 hours and 7 to 9 hours ( $P = 0.02$ ).

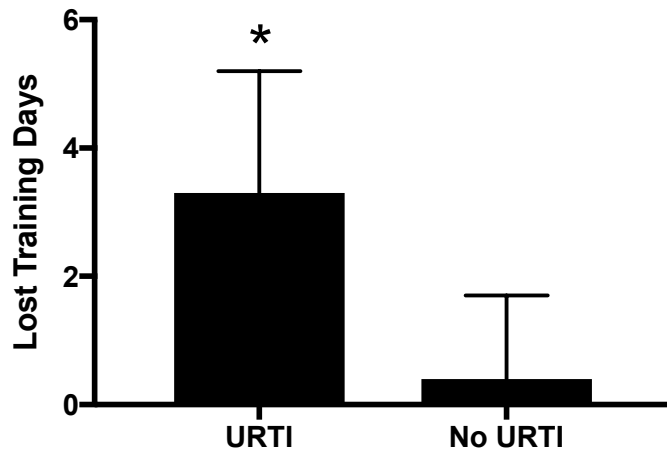


373

374

375

376 **Figure 3.** Recruits diagnosed with URTI had more lost training days for any illness than recruits  
377 not diagnosed with URTI (\* $P < 0.01$ ). Data are presented as mean  $\pm$  SD.



378

379