Sleep Health 3 (2017) 126–131

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

Using actigraphy feedback to improve sleep in soldiers: an exploratory trial[☆]

Amy B. Adler, PhD [a,*], Brian C. Gunia, PhD [a,b], Paul D. Bliese, PhD [a,c], Paul Y. Kim, MA [a], Matthew L. LoPresti, PhD [a,1]

[a] Walter Reed Army Institute of Research, 503 Robert Grant Ave, Silver Spring, MD 20910, USA
[b] Johns Hopkins University, Carey Business School, 100 International Dr, Baltimore, MD 21202, USA
[c] University of South Carolina, Darla Moore School of Business, 1014 Greene St, Columbia, SC 29208, USA

ARTICLE INFO

Article history:
Received 20 April 2016
Received in revised form 24 December 2016
Accepted 6 January 2017

Keywords:
Actigraph
Soldiers
Nudges
Military
High-risk occupation

ABSTRACT

Objectives: The objective of this study was to assess the impact of wearing an actigraph and receiving personalized feedback on the sleep of a high-risk occupational group: United States soldiers recently returned from a combat deployment.
Design: Following a baseline survey with a full sample, a subsample of soldiers wore an actigraph, received feedback, and completed a brief survey. Two months later, the full sample completed a follow-up survey. The actigraph intervention involved wearing an actigraph for 3 weeks and then receiving a personalized report about sleep patterns and an algorithm-based estimate of cognitive functioning derived from individual sleep patterns.
Results: Propensity score matching with a genetic search algorithm revealed that subjects in the actigraph condition (n = 43) reported fewer sleep problems (t value = −2.55, $P < .01$) and getting more sleep hours (t value =1.97, $P < .05$) at follow-up than those in a matched comparison condition (n = 43, weighted). There were no significant differences in functioning, somatic symptoms, and mental health outcomes (posttraumatic stress disorder symptoms and depression). A significant interaction indicated that the actigraph had a more beneficial effect on those with more somatic symptoms at baseline but not those with more sleep problems. Most participants rated the personalized report as helpful.
Conclusion: Actigraphs combined with personalized reports may offer a useful, simple intervention to improve the sleep patterns of large, high-risk occupational groups.

Introduction

Sleep problems such as short sleep duration and insomnia are risk factors for mental health problems[1] and impaired cognitive functioning.[2] Furthermore, the negative effects of sleep problems may be exacerbated in high-risk occupations with elevated incidence of mental health problems.[3]

One possible way to improve sleep is through increased self-awareness, and one way to improve self-awareness is through actigraphy. Wrist-worn actigraphs measure movement acceleration from which sleep/wake timing and duration are estimated. These devices have been validated against polysomnography in both normal sleepers[4,5] and adults with insomnia.[6] Not only do actigraphs track sleep patterns, but the data can be converted into an estimate of cognitive functioning based on an algorithm developed by the Walter Reed Army Institute of Research.[7,8] This algorithm was developed using psychomotor vigilance test data from laboratory studies of sleep restriction and sleep deprivation,[9] with color codes (green, amber, and red) reflecting the comparable level of impairment that results from various blood alcohol concentration levels. There is also a graph of "cognitive effectiveness" that can be generated as part of a personalized report. This graph is color coded to indicate the likelihood of good, moderate, and poor cognitive performance.[10]

Research has shown that increasing personal awareness of health-related behaviors is associated with improved health habits, such as eating, smoking and exercise,[11] and providing normative feedback alone can result in changed behavior, such as reduced

☆ Author contributorship: AA and ML designed the study; AA, PK, and ML collected the data; BG, PB, and PK conducted the analyses. All authors interpreted the data, contributed to writing, and approved the final manuscript.

* Corresponding author. Tel.: +1 301 319 9444; fax: +1 301 319 9484.
E-mail address: amy.b.adler.civ@mail.mil (A.B. Adler).
1 Present address: The United States Army Medical Research Directorate-West, 9933 West Hayes St, Joint Base Lewis McChord, WA 98431, USA.

http://dx.doi.org/10.1016/j.sleh.2017.01.001
2352-7218/Published by Elsevier Inc. on behalf of National Sleep Foundation.

alcohol consumption.[12] Presumably, providing individuals with feedback about their sleep patterns and cognitive functioning status can produce similar change. Simple sleep-related interventions can build on the concept of health-related "nudges." Nudges increase the likelihood of certain behaviors by altering subtle features of the surrounding environment[13]; for instance, presenting calorie information using heuristic accentuation (eg, traffic lights, letter grades) tends to encourage healthy eating.[14]

Although the literature on nudges has not, to our knowledge, investigated sleep-related nudges, informing individuals about the link between their unique sleep patterns and cognitive functioning may motivate change by clarifying the cognitive benefits or consequences of sleep patterns over which individuals have some control. We hypothesized, therefore, that an actigraph feedback intervention would be associated with better sleep.

In a series of secondary research questions, we also examined distal outcomes associated with sleep problems: functioning,[15,16] somatic symptoms,[15,17] and mental health problems (such as posttraumatic stress disorder [PTSD] and depression).[18] In addition, we examined whether the intervention was particularly beneficial for individuals already experiencing sleep, functioning, somatic, and mental health problems at baseline because they have the most to gain from an intervention. Finally, we examined user acceptability of wrist actigraphy and a personalized report.

To investigate the impact of actigraph feedback, we sampled from a population known to be at risk for significant sleep problems: soldiers recently returned from combat.[19] Previous studies have documented substantial sleep problems in this group, especially among those who experienced combat-related events,[20,21] and have demonstrated links to functional impairment,[22] somatic symptoms, PTSD, and depression[3,21] in service members returning from combat. Adequate sleep and cognitive functioning are particularly important in occupational groups such as the military where accidents brought on by lapses in judgment can have serious consequences.[23,24]

Participants and methods

Participants

Study participants were active-duty US soldiers from one brigade that completed a 6-month combat deployment to Afghanistan. Soldiers were surveyed 1 month after returning from the deployment (time 1; T1) in February-April 2014 and again 3 to 4 months later (time 2; T2) in June and July 2014. Prior to enrollment, participants provided informed consent under a protocol approved by the Institutional Review Board at Walter Reed Army Institute of Research; 2914 of the 3469 soldiers who attended the recruitment briefing consented to participate (84%).

Of the 2914 in the T1 sample pool, 115 were offered an opportunity to participate in the actigraph condition. The only inclusion criterion for this phase was that the individual expected to be available for the follow-up survey. Two declined because they did not like wearing watches; 113 agreed (98%). Subsequently, 1 watch failed, 2 were not returned, and 2 were not worn, resulting in 108 who completed the actigraph portion of the study. Given that surveys were anonymous and linked over time using a personalized code, some surveys were not able to be matched over time because codes were mismatched or blank, consistent with other efforts to use this approach.[25] Moreover, individuals were not necessarily available for follow-up because of competing work-related requirements, consistent with other studies conducted with military units.[26] Consequently, of the 108 participants in the actigraph condition, we were able to link 95 to their T1 survey, and of those, 66 were linked to the postactigraph survey, and 43 were then linked to their T2 survey. Our analyses use these 43 participants because they provided outcome values and T2 and had completed all phases of the study (n sizes used for calculations vary slightly due to missing variables).

The original 113 actigraph participants were selected from a range of companies across 1 battalion. Because information from this study was being used to inform a separate project examining sleep and junior leaders, we oversampled junior officers (eg, lieutenants) in the actigraph portion of the study. According to battalion leadership, individuals were selected arbitrarily; however, we cannot exclude the possibility that the 113 participants represent a convenience sample. In the nonactigraph condition, 1102 participants from T1 were surveyed again at T2. See Table 1 for a comparison between the full nonactigraph sample and the full actigraph sample at T1, as well as T1 data from the actigraph sample linked across all 3 time periods (T1, postactigraph, and T2).

Procedure

As part of a large-scale data collection on postdeployment adjustment, subjects were assembled in a gymnasium or large conference room on a US military post in Germany. After being briefed, individuals provided their informed consent; to reduce the possibility of undue influence, leaders were separately briefed and consented. The baseline survey was then administered in this large-group setting. As noted, both the baseline survey and the follow-up survey were part of a broader longitudinal study; here, we only report items relevant to the current analyses. Within a day of the baseline survey, individuals from this baseline sample were selected and assigned to the actigraph condition. There were no other specific selection criteria. Individuals were then briefed, consented, and fitted with a wrist-worn actigraph. The specific device was the Fatigue Science Readiband 3 (Sleep Performance Inc), which continuously monitored wearer movement. Participants were instructed to wear the actigraph at all times and that the device would not transmit their data to any external sources, ensuring privacy. At the end of the 3-week wear period, the actigraphs were collected by study staff, and the data were downloaded to a computer for analysis using software specifically designed for this device. This software scored the movement data into sleep/wake periods using standardized algorithms for actigraphy-based sleep analysis.[27] Prior to generating individual reports, the data were edited to ensure that only periods where the actigraph was actually worn were included in the report, following standardized procedures for excluding invalid data whereby extended periods with zero activity (eg, device was removed) were "cropped" out of the data set to avoid those periods being inaccurately coded as sleep. Two days later, participants returned to receive their personalized reports and briefly reviewed the content of the report with a study staff member. A sample report is included in a Supplemental file.

The personalized report included several sections: (1) sleep data from the previous 3 weeks highlighting daily activity and sleep/wake scoring; (2) summary sleep data comparisons with data from the general US population, including average total sleep time per 24 hours, time of nightly sleep onset, sleep onset time variability, and sleep efficiency (scores differing from the norm were indicated with an asterisk); (3) cognitive functioning estimates mapped onto green, amber, and red bands based on the individual's sleep data and algorithms from previous studies[9]; and (4) recommended actions for improving sleep. Each report section was identified. For the sleep section, it was explained that the lines going up indicated activity and the lines that were low and flat indicated periods of sleep. It was then explained that scores outside of the norm were identified with an asterisk. Next, participants were told that their cognitive functioning pattern was graphed for the period of time that they wore the actigraph, and that any scores in the green band indicated optimal cognitive functioning and scores in the red band