International Journal of
EXERCISE SCIENCE

Original Research

Sleep-hygiene Education improves Sleep Indices in Elite Female Athletes

SHANNON O'DONNELL† and MATTHEW W. DRILLER‡

University of Waikato, Hamilton, NEW ZEALAND

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 10(4): 522-530, 2017. The importance of sleep in providing psychophysiological recovery in elite athletes is often overlooked**.** In other populations (eg shift workers and adolescent students), sleep hygiene education may serve to acutely improve sleep indices. However, this is yet to be examined in an elite athlete setting. Therefore, the aim of the current study was to evaluate the effect of a sleep hygiene education session on sleep indices in elite athletes. The study involved 26 elite female netball athletes performing one week of baseline sleep monitoring (PRE), followed by a sleep hygiene education session and a further week of sleep monitoring (POST) in a single group, pre- post design. The sleep hygiene education session focused on providing information on the importance of sleep for athletes and practical tips to improve sleep quality and quantity. Sleep monitoring was performed using wrist actigraphy to assess total sleep time (TST), sleep efficiency (SE%), total time in bed (TTB), sleep latency (SL), wake episodes per night (WE), sleep onset variance (SOV), wake variance (WV) wake episode duration (WED), sleep onset time (SOT), and wake time (WT). There was a significant improvement in TST (mean ± SD; 22.3 ± 39.9 minutes, p=0.01) PRE to POST sleep hygiene education session, the difference associated with a *small* effect (ES: 0.39). A significant improvement PRE to POST was found for WV (p=0.03), and for WED (p=0.03). There were no significant differences for SE%, SL, TTB, WE, SOV, SOT, WT. The current study reports that a sleep hygiene education session is effective in improving sleep quantity in elite female athletes in an acute setting.

KEY WORDS: Recovery, netball, sport

INTRODUCTION

Elite sporting success is underpinned by optimal preparation as well as adequate recovery between training and competition. There is increasing recognition that sleep has a significant role in the performance and recovery of highly-trained athletes (10). According to Halson (10) and Leeder et al., (17), sleep quality and quantity is reported to be the single best psychological and physiological recovery strategy available to elite athletes. However, elite athletes often experience inadequate sleep compared with non-athletes (25). Lastella (16) reported that on average, elite athletes obtain 6.8 hours of sleep per night. Furthermore a study by Leeder et al. (17) reported elite female athletes on average obtain 6 hours 56 minutes of sleep. Despite the importance of sleep on athletic performance and recovery, it has been reported that there is limited data on the use of sleep interventions to improve sleep in elite athletes (7, 13, 22).

Recent research has shown that due to a number of factors, elite athletes sleep may actually be inferior when compared to the general population. The increase in core temperature following exercise (22), increase in muscle tension and pain following training and competition (11), disruption from light and noise and increase in psychological stress (8) are thought to be contributing factors. More than half (52.3%) of the athletes from a sample of 283 elite (individual and team sport) athletes, reported suffering sleep disturbances following a late training session or competition (13). Furthermore, a study by Eagles et al., (7) found a significant reduction in sleep quantity in professional rugby union players following game nights compared to non-game nights. The time taken to fall asleep was also significantly longer following a game night compared to a non-game night.

It is thought that sleep hygiene education may help to improve sleep quality and quantity (27). Sleep hygiene is described as practicing behaviors that facilitate sleep and avoiding behaviors that interfere with sleep (11, 15, 20, 27). Sleep hygiene education includes the provision of advice based on various aspects of lifestyle and behavior as well as environmental factors that influence sleep such as light, noise and temperature (14, 23, 26). The education of sleep and sleep hygiene practices provides athletes with strategies to maximize the amount and quality of the sleep they obtain (16). A study by Kakinuma et al., (14) evaluated the effect of a sleep hygiene education session in the workforce of an information technology company. Participants (n=391) attended a 50-minute lecture on the role of sleep and the proper sleep environment to promote sleep, followed by a 10-minute question and answer period. The results showed that four weeks following a 1-hour sleep hygiene education session, daytime sleepiness at 14:00 significantly decreased ($p<0.05$). Sousa et al. (26) investigated the effectiveness of a daily 50 minute sleep hygiene educational program for one week on sleep quality and sleepiness in adolescent students (n=58), with findings showing a significant decrease in sleep latency from 13 to 9 minutes following the sleep hygiene education session ($p<0.01$).

Several other studies have investigated the use of sleep hygiene education programs in a number of different populations with varying levels of success (3, 9, 23), however, to our knowledge, the use of a sleep hygiene education session is yet to be studied in an elite athlete population. Therefore, the aim of the present study was to evaluate the effects of a single sleep hygiene education session on the sleep quality and quantity of female netball athletes over an acute period of time (two weeks) during a pre-season, heavy phase of training.

METHODS

Participants

A total of 26 elite female netball athletes (mean ± SD; age = 23 ± 6 y,) volunteered to participate in the current study. Athletes were of international and/or national representative standard (19 and 7, respectively) and the study took place in the pre-season phase of competition. All participants provided informed written consent before taking part in this study. Ethical approval for the study was obtained through the institutions Human Research Ethics Committee.

Protocol
The current study was performed using a single group pre-post design whereby athletes performed one week of baseline sleep monitoring (PRE) followed by a sleep education session and a further week of sleep monitoring (POST). The study took place during the pre-season phase of training, which included approximately 9 training sessions per week spread over 6 days, with a single rest day each week (3 x gym, 4 x on-court sessions, 2 x aerobic conditioning sessions). All training sessions were performed before 15:00 daily and total training volume was approximately 15 hours per week. Both PRE and POST weeks were identical in terms of training schedules and were matched for training intensity and duration by the coaches working with the researchers, to ensure that biological variations and hormonal responses to training were kept similar between weeks. Although not monitored in the current study, athletes were also asked to maintain a normal diet during PRE and to replicate this diet during POST.

Sleep Monitoring - Participants were required to wear a wrist actigraphy device (Fatigue Science, Readiband) as used by Dennis et al., (5), over a 2-week (14 day) period to monitor sleep patterns. The raw activity scores were translated to sleep-wake scores based on computerized scoring algorithms (24). The inter-device reliability of the Readiband actigraph device has been deemed acceptable as described elsewhere (6). Actigraphy has been shown to be valid and reliable in normal healthy adult populations (1, 24), and is commonly used in sporting teams as it is more practical and less intrusive compared to polysomnography (PSG) (5). A further benefit of using actigraphy is that participants can monitor their sleep patterns in their own home environment. The five measures obtained from the actigraphy device that were used as sleep indices are described in Table 1 (6).

Participants were each allocated an actigraph at the start of the first week (day one - PRE). The participants were instructed to wear the actigraph on their non-dominant wrist (5), for 14 days. Participants were required to wear the actigraph continuously for the 14-day period, with the exception of time spent during on-court training sessions. Participants were instructed to maintain their usual sleep habits and patterns for this first week of sleep monitoring (day 1 – day 8, PRE), and then to implement the advice given at the sleep education session for the second week of monitoring (day 8 – day 14, POST). At the conclusion of the 14 day period, actigraph devices were collected and the data was retrieved using Fatigue Science software (16Hz sampling rate: Readiband, Fatigue Science, Vancouver). The results from the second week (day 8 – day 14, POST) were used against the first week's results (PRE) to assess the effect of the sleep education session on sleep quality and quantity.

Sleep Education Session - All participants attended a sleep education session at the conclusion of the first week of sleep monitoring (day 8 - PRE). The sleep education session was provided by a specialist in sleep research and athletic recovery. The education session included a presentation on the importance of sleep for athletes, sleep physiology and sleep hygiene for 50 minutes, followed by a 10-minute question and answer period. The presentation focused on normal human sleep and the role and mechanisms of sleep. Sleep hygiene information was presented to the participants, with instructions given on how to implement correct sleep hygiene practices into their sleep habits and routines. The sleep hygiene education focused on the following 5 practical tips: maintaining a regular bed and wake time, ensuring a quiet, cool and dark bedroom environment, avoidance of caffeine and other stimulants prior to sleep, avoidance of light-emitting technology devices in the hours prior to sleep and implementation of relaxation strategies before bed (e.g progressive muscle relaxation (21). Participants were encouraged to implement the sleep hygiene advice given to them during the sleep education session into their own sleeping habits and routines for the second week of monitoring. While not measured in the current study, athletes were constantly reminded (daily) to make sure they were implementing the tips during the POST monitoring period, and gave anecdotal feedback that they were adhering to the suggested recommendations.

Table 1. Definitions of each sleep variable measured through wrist-actigraphy. Adapted from M. Driller, J. McQuillan, and S. O'Donnell (6).

Sleep Indices	**Units**	**Description**
Total Sleep Time (TST)	Minutes	Total time spent asleep
Sleep Efficiency (SE)	%	Total time in bed divided by total sleep time
Total Time in Bed (TTB)	Minutes	Total time spent in bed
Sleep Latency (SL)	Minutes	Time taken for sleep onset
Wake Episodes per Night (WE)	Number count	Total number of awakenings per night
Sleep Onset Variance (SOV)	Minutes	Sleep onset consistency relative to mean
Wake Variance (WV)	Minutes	Wake time consistency relative to mean
Wake Episode Duration (WED)	Minutes	Mean wake episode duration
Sleep Onset Time (SOT)	Time of day	Time of transition from wakefulness into sleep
Wake Time (WT)	Time of day	Wake up time for the sleep period

Statistical Analysis

Simple group statistics are shown as means ± standard deviations unless stated otherwise. A Microsoft Excel spreadsheet was used to estimate the mean effects and 90% confidence intervals (90%CI) of the education session (12). Excluding sleep efficiency, data were log-transformed to reduce non-uniformity of error (12). Magnitudes of the standardized effects were calculated using Cohen's *d* and interpreted using thresholds of 0.2, 0.6 and 1.2 for *small, moderate and large*, respectively (2). An effect size of <0.2 was considered to be *trivial* and the effect was deemed *unclear* if its 90% confidence interval overlapped the thresholds for small positive and negative effects (±0.2) (2). A students paired T-test was used to compare PRE and

POST using a Statistical Package for Social Science (V. 22.0, SPSS Inc., Chicago, IL), with statistical significance set at $p \leq 0.05$.

RESULTS

There was a significant increase in TST from PRE to POST following the sleep hygiene education session (p=0.008). The TST from PRE to POST showed an average increase of 22.3 ± 39.9 minutes (Table 2), this difference was associated with a *small* effect size (ES: 0.39). There was a significant decrease in WV (p=0.03) PRE to POST, the difference was associated with a *moderate* effect size (ES: -0.70) and an average decrease of 21.2 ± 34.6 minutes (Table 2). A significant decrease was observed in WED (p=0.03) PRE to POST, the difference was associated with a *small* effect size (ES: -0.57).

Table 2. Mean ± SD values for the measured sleep variables PRE and POST a sleep hygiene education session, including the absolute PRE to POST change, p-values and Effect Sizes (±90% confidence intervals).

	PRE	POST	Absolute Change (PRE / POST)	P-Value	PRE – POST Effect Size (±90% Confidence Intervals)
Total Sleep Time (mins)	436.0 ± 50.5	458.3 ± 54.8	22.3 ± 39.9	<0.01	0.39 ±0.24 *Small*
Sleep Efficiency (%)	80.6 ± 6.5	82.6 ± 6.7	2.6 ± 5.7	0.11	0.26 ±0.28 *Small*
Total Time in Bed (mins)	545.3 ± 46.7	552.5 ± 44.1	7.2 ± 47.6	0.45	0.15 ±0.34 *Trivial*
Sleep Latency (mins)	28.6 ± 15.6	26.0 ± 15.0	-2.6 ± 12.5	0.29	-0.27 ±0.39 *Small*
Wake Episodes (No. per night)	3.9 ± 2.0	4.1 ± 2.2	0.2 ± 2.1	0.37	0.16 ±0.31 *Trivial*
Sleep Onset Variance (mins)	46.9 ± 23.7	39.9 ± 16.1	-6.7 ± 29.1	0.25	-0.21 ±0.44 *Unclear*
Wake Variance (mins)	72.1 ± 28.7	50.9 ± 21.0	-21.2 ± 34.6	0.03	-0.70 ±0.62 *Moderate*
Wake Episode Duration (WED)	14.1 ± 5.4	11.1 ± 4.0	-3.3 ± 6.6	0.03	-0.57 ±0.57 *Small*
Sleep Onset Time (time of day)	23:13 ± 0:41	23:02 ± 0:46	-11.0 ± 47.9	0.28	-0.18 ±0.43 *Unclear*
Wake Time (time of day)	8:02 ± 0:45	8:31 ± 0:51	29.0 ± 53.9	0.06	0.20 ±0.51 *Unclear*

SE showed an average increase of 2.6 ± 5.7% resulting in a *small* but not statistically significant difference PRE to POST (ES: 0.26, p=0.11). SL showed an average decrease of 6.7 ± 29.1 minutes

PRE to POST. The difference was not statistically significant (p=0.29), however SL was associated with a *small* effect size (ES: -0.27).

Results for TTB (p=0.45), SOV (p=0.25), WE (p=0.37), SOT (p=0.28), and WT (p=0.06) were not significantly different PRE to POST the sleep hygiene education session. The difference PRE to POST was associated with a *trivial* effect size for TTB (ES: 0.15) and WE (ES: 0.16), and *unclear* effects for SOV, SOT and WT.

DISCUSSION

The current study is the first to show that a sleep hygiene education may be used to improve sleep in elite athletes. A single one-hour session of sleep hygiene education resulted in a significant improvement in total sleep time and wake variance, with 22 minute and 21 minute improvements, respectively, from pre to post education in 26 elite female athletes. Whilst there were no significant differences for the other sleep indices, there were some trends towards improvements in total time in bed, sleep efficiency and sleep latency pre to post education. The findings provide evidence that a sleep education session may be useful in improving both sleep quantity and quality of elite athletes in an acute setting of two weeks. Further research is required to establish whether these improvements could translate to improved sleep in a chronic setting.

The results of the current study are consistent with previous studies that have assessed the effect of sleep hygiene education sessions on sleep (9, 14, 23, 26). Most of the previous studies, however, have involved participants whom suffer from sleep disturbances or complaints, rather than athletic populations (3, 9, 27). The study by Gebhart et al. (9) assessed sleep hygiene education effectiveness combined with physical exercise in individuals with sleep disturbances. Participants (n=114) were either assigned to the waiting list group (control) or the intervention group (a 6 week sleep hygiene education and physical exercise intervention). Results showed significant improvements in sleep quality (p<0.001), sleep latency (p<0.05) and sleep duration (p<0.01) in the intervention group from baseline to 6-weeks. While we found similar results for some sleep indices, the current study differs to the Gebhard et al. study, through the use of athletes as the participants. Furthermore, in the current study, participants were only exposed to a single one-hour sleep hygiene education session, as opposed to six one-hour sleep hygiene education sessions. It can be assumed that the addition of further education sessions may result in even more significant findings than those found in the current study.

Similar to the current study, Kakinuma et al. (14) evaluated the effect of a one-hour sleep hygiene education session in healthy participants of an information technology company. The results showed a significant decrease (p=0.04) in daytime sleepiness at 14:00, four weeks following the one-hour sleep hygiene education session. The education session focused on the role and mechanisms of sleep and outlined the proper environment to promote sleep. Although not statistically significant, perceived sleep quality appeared to improve as measured through the Pittsburgh Sleep Quality Index (0.67-point decrease). Nishinoue et al.

(23) performed a randomized, controlled trial to evaluate how sleep quality is affected by a sleep hygiene education session combined with one-on-one behavioral therapy. Healthy adult participants (n=121) were randomly assigned to either the control group (a group-based sleep hygiene education session) or the intervention group (a sleep hygiene education session combined with 30-minutes of individual behavioral training), with results showing a significant improvement on the global Pittsburgh Sleep Quality Index score in both the intervention ($p<0.01$) and control ($p<0.05$) groups from baseline to three months following the completion of the intervention. The results from the two studies confirm the results found in the current study pertaining to statistical differences in the majority of measured sleep indices.

It has been reported in previous research that on average athletes obtain 6.8 hours of sleep per night (16), with athletes from individual sports obtaining closer to 6.5 hours and team sport athletes obtaining ~7.0 hours per night (16). The results pre and post the sleep hygiene education session in the current study showed the athletes obtained 7.3 hours and 7.6 hours of sleep, respectively, indicating a similar, if not longer total sleep time than that of other team sport athletes. Previous research has reported, disturbances to both sleep quantity and quality has implications for psychological and physical recovery following training sessions (8). Due to the restorative benefits provided through sleep for athletes, such as hormonal responses and cognitive performances (4), disruptions in sleep indices may consequently have a negative effect on recovery and performance. A study by Leeder et al. (17) researched normative sleeping patterns of elite athletes. The results of their study reported that elite female athletes on average obtained 6 hours 56 minutes of sleep. Sleep latency was 12.7 minutes on average and sleep efficiency was reported as 83.9% (17). Comparable to the current study, our post results were 26 minutes and 82.6% for sleep latency and sleep efficiency, respectively. Although difficult to draw comparisons between the two studies, due to the differences in methods and protocols, the comparison between sleep measures is important due to the limited data on elite athletes. While the TST was similar between studies, the difference in sleep latency appears considerably greater in the current study. A possible reason for this difference was that some training sessions took place in the afternoon during summer in the current study, which could have caused an increase in core temperature in the evening, delaying the onset of sleep.

Limitations of the current study were that the sleep measurements were limited to the use of an objective measure only (actigraphy). The use of sleep logs/diaries and sleep hygiene questionnaires as subjective measures would have provided more detail on the effect of the sleep hygiene education session. While the researchers received anecdotal feedback that the hygiene tips were being practiced, monitoring the adherence to the sleep hygiene advice would have been advantageous in determining what factors may have effected sleep indices. A follow-up of whether these practices had been adhered to in the months following the education session may also provide interesting information. The addition of a control group (no education session) to the experimental design, may have allowed for further comparisons of the sleep-hygiene education. The authors acknowledge that information on the phase of each participant's menstrual cycle may have been appropriate, as this has been shown to have an influence on sleeping patterns (19). More thorough control of diet would be also advantageous in future research. Evaluation of chronic behavioural change including both qualitative and quantitative data following an education session would provide further insight into the efficacy of sleep hygiene education and a worthwhile addition to future research. Future research in the athlete setting may also include performance measures pre and post sleep education to evaluate the effect of sleep indices on athletic performance. Indeed, Mah et al. has shown that sleep extension over 10-weeks in college basketball athletes lead to improvements in total sleep time, psychomotor vigilance tasks, daytime sleepiness and mood (18).

The current investigation is the first to show that a one-hour sleep hygiene education session has a positive acute effect on improving sleep quantity in elite female athletes. Given adequate sleep is crucial for aiding in the psychological and physiological recovery of an athlete, the findings from this study provide evidence to the importance of educating athletes about sleep and optimal sleep hygiene.

REFERENCES

1. Ancoli-Israel S, Cole R, Alessi C, Chambers M, Moorcroft W, Pollak C. The role of actigraphy in the study of sleep and circadian rhythms. Sleep 26(3):342-392, 2003.

2. Batterham A, Hopkins W. Making meaningful inferences about magnitudes. Int J Sports Physiol Perform 1(50):50-57, 2006.

3. Chen P, Kuo H, Chueh K. Sleep hygiene education: efficacy on sleep quality in working women. J Nurs Res 18(4):283-289, 2010.

4. Davenne D. Sleep of athletes - problems and possible solutions. Biological Rhythm Research 40(1):45-52, 2009.

5. Dennis J, Dawson B, Heasman J, Rogalski B, Robey E. Sleep patterns and injury occurrence in elite Australian footballers. J Sci Med Sport 19(2): 113-116, 2016.

6. Driller M, McQuillan J, O'Donnell S. Inter-device reliability of an automatic-scoring actigraph for measuring sleep in healthy adults. Sleep Sci 9(3): 198-201, 2016.

7. Eagles A, Mclellan C, Hing W, Carloss N, Lovell D. Changes in sleep quantity and efficiency in professional rugby union players during home based training and match-play. J Sports Med Phys Fitness [Epub ahead of print], 2014.

8. Fullagar H, Duffield R, Skorski S, Coutts A, Julian R, Meyer T. Sleep and recovery in team sport: current sleep-related issues facing professional team-sport athletes. Int J Sports Physiol Performance 10:950-957, 2015.

9. Gebhart C, Erlacher D, Schredl M. Moderate exercise plus sleep education improves self-reported sleep quality, daytime mood, and vitality in adults with chronic sleep complaints: a waiting list-controlled trial. Sleep Disorders article 809312, 2011.

10. Halson S. Sleep and the elite athlete. Sports Sci Exchange 26(113):1-4, 2013.

11. Halson S. Sleep in elite athletes and nutritional interventions to enhance sleep. Sports Med 44(1):13-23, 2014.

12. Hopkins W. Spreadsheets for analysis of validity and reliability. Sports Sci 19:36-42, 2015.

13. Juliff L, Halson S, Peiffer J. Understanding sleep disturbance in athletes prior to important compeititons. J Sci Med Sport 18:13-18, 2015.

14. Kakinuma M, Takahashi M, Kato N, Aratake Y, Watanabe M, Ishikawa Y, Kojima R, Shibaoka M, Tanaka K. Effect of brief sleep hygiene education for workers of an information technology company. Ind Health 48:758-765, 2010.

15. Lacks P, Rotert M. Knowledge and practice of sleep hygiene techniques in insomniacs and good sleepers. Behav Res Ther 24(3):365-368, 1986.

16. Lastella M, Roach G, Halson S, Sargent C. Sleep/wake behaviours of elite athletes from individual and team sports. Eur J Sport Sci 15(2):94-100, 2014.

17. Leeder J, Glaister M, Pizzoferro K, Dawson J, Pedlar C. Sleep duration and quality in elite athletes measured using wristwatch actigraphy. J Sports Sci 30(6):541-545, 2012.

18. Mah C, Mah K, Kezirian E, Dement W. The effects of sleep extension on the athletic performance of collegiate basketball players. Sleep 34(7):943-950, 2011.

19. Manber R, Bootzin R. Sleep and the menstrual cycle. Health Psychol 16(3):209-214, 1997.

20. Mastin D, Bryson J, Corwyn R. Assessment of sleep hygiene using the sleep hygiene index. J Behav Med 29(3):223-227, 2006.

21. McCloughan L, Hanrahan S, Anderson R, Halson S. Progressive muscle relaxation (PMR), sleep, and recovery in elite performers. J Sci Med Sport 18:113, 2014.

22. Nedelec M, Halson S, Abaidia A, Ahmaidi S, Dupont G. Stress, sleep and recovery in elite soccer: a critical review of the literature. Sports Med 45:1387-1400, 2015.

23. Nishinoue N, Takano T, Kaku A, Eto R, Kato N, Ono Y, Tanaka K. Effects of sleep hygiene education and behavioral therapy on sleep quality of white-collar workers: a randomized controlled trial. Industrial Health 50:123-131, 2012.

24. Sadeh A. The role and validity of actigraphy in sleep medicine: an update. Sleep Med Rev 15:259-267, 2011.

25. Simpson N, Gibbs E, Matheson G. Optimizing sleep to maximize performance: implications and recommendations for elite athletes. Scand J Med Sci Sports 27(3):266-274, 2016.

26. Sousa I, Araujo J, Azevedo C. The effect of a sleep hygiene education program on the sleep-wake cycle of Brazilian adolescent students. Sleep Biol Rhythms 5:251-258, 2007.

27. Stepanski E, Wyatt J. Use of sleep hygiene in the treatment of insomnia. Sleep Med Rev 7(3):215-225, 2003.