Journal of Science and Medicine in Sport xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Understanding sleep disturbance in athletes prior to important competitions

Laura E. Juliff[a,b,c,*], Shona L. Halson[a], Jeremiah J. Peiffer[b]

[a] Performance Recovery, Australian Institute of Sport, Australia
[b] School of Psychology and Exercise Science, Murdoch University, Australia
[c] Physiology, Australian Institute of Sport, Australia

ARTICLE INFO

Article history:
Received 14 October 2013
Received in revised form
22 December 2013
Accepted 5 February 2014
Available online xxx

Keywords:
Sleep complaints
Sleep strategies

ABSTRACT

Objectives: Anecdotally many athletes report worse sleep in the nights prior to important competitions. Despite sleep being acknowledged as an important factor for optimal athletic performance and overall health, little is understood about athlete sleep around competition. The aims of this study were to identify sleep complaints of athletes prior to competitions and determine whether complaints were confined to competition periods.
Design: Cross-sectional study.
Methods: A sample of 283 elite Australian athletes (129 male, 157 female, age 24 ± 5 y) completed two questionnaires; Competitive Sport and Sleep questionnaire and the Pittsburgh Sleep Quality Index.
Results: 64.0% of athletes indicated worse sleep on at least one occasion in the nights prior to an important competition over the past 12 months. The main sleep problem specified by athletes was problems falling asleep (82.1%) with the main reasons responsible for poor sleep indicated as thoughts about the competition (83.5%) and nervousness (43.8%). Overall 59.1% of team sport athletes reported having no strategy to overcome poor sleep compared with individual athletes (32.7%, $p = 0.002$) who utilised relaxation and reading as strategies. Individual sport athletes had increased likelihood of poor sleep as they aged. The poor sleep reported by athletes prior to competition was situational rather than a global sleep problem.
Conclusion: Poor sleep is common prior to major competitions in Australian athletes, yet most athletes are unaware of strategies to overcome the poor sleep experienced. It is essential coaches and scientists monitor and educate both individual and team sport athletes to facilitate sleep prior to important competitions.

1. Introduction

Within elite sport, success is underpinned by optimal preparation[1] and, equally important, adequate recovery between training and during competition.[2,3] Sleep has been recognised as an essential component for athlete preparation and is suggested to be the single best recovery strategy available to an athlete.[4,5] Despite the importance of sleep for athletic performance, data on elite athletes is limited.[5] Anecdotal reports suggest athletes often sleep worse around competition periods, particularly the night(s) prior to an important competition.[6,7] With reduced sleep shown to negatively influence performance this reduction may become problematic.[8,9] Sleep deprivation studies in athletes has found decreased anaerobic performances through decreased mean and total sprint time in team sport athletes after 30 h of sleep deprivation[10] and decreased aerobic performance following 24 h of reduced sleep.[11] Whilst it may be seldom that athletes experience total sleep deprivation prior to competition, acute partial sleep deprivation may exist. One night of poor sleep in athletes is associated with reduced reaction times,[12] reduced anaerobic performance the following afternoon in football players[13] and declines in cognitive processes such as visual tracking, focus, determination and mood.[14,15] As many sports rely on fine motor movements and the ability to make fast accurate decisions, reduced sleep in athletes is a genuine concern.[16]

As it is possible that sleep quantity and quality may influence performance,[17] there is a growing need to understand sleep patterns in elite athletes. To date, relatively few studies exist that provide this information.[3,19,20] In a survey of 632 German athletes prior to competition, 65.8% acknowledged worse sleep than normal at least once before a competition, indicating their main issue to be "problems falling asleep" (79.9%), due to "thoughts about

* Corresponding author.
E-mail address: laura.juliff@ausport.gov.au (L.E. Juliff).

http://dx.doi.org/10.1016/j.jsams.2014.02.007
1440-2440/

Table 1
Distribution of athletes by sport.

Individual	Team
Athletics $n = 21$	Basketball $n = 14$
Canoe/Kayak $n = 6$	Football (soccer) $n = 24$
Cycling $n = 17$	Hockey $n = 30$
Gymnastics $n = 3$	Netball $n = 30$
Moguls $n = 1$	Rugby League $n = 15$
Rowing $n = 4$	Rugby Sevens $n = 44$
Sailing $n = 2$	Softball $n = 14$
Short Track Speed Skating $n = 1$	Volleyball $n = 10$
Ski Cross $n = 3$	Waterpolo $n = 4$
Surf Life Saving $n = 1$	Wheelchair Basketball $n = 19$
Swimming $n = 9$	Wheelchair Rugby $n = 6$
Tennis $n = 3$	
Triathlon $n = 1$	
Power Lifting $n = 1$	

the competition/game" (77%) and because of this "increased daytimes sleepiness" with athletes indicating "no special strategy" to enhance sleep.[6] These findings provide valuable information on sleep habits of the elite athlete and provide a stimulus for further investigation. Furthermore, if elite athletes do present as "poor" sleepers it is important to differentiate poor competition sleep from chronic sleep issues if coaches, athletes and sports scientists hope to use this knowledge to enhance future performance.

The purpose of this study was to document the occurrence of sleep disturbances in athletes prior to important competitions and/or games. If sleep disturbances were indicated by athletes, we aimed to examine the particular problems, reasons and perceived consequences associated with the sleep disturbance. In addition from the information obtained we sought to determine whether a particular group of athletes had an increased likelihood of sleep disturbance. This study additionally aimed to provide a comprehensive analysis of whether individual versus team sport athlete sleep habits differ. Finally, a novel aspect of the study was to establish whether sleep disturbances are a general complaint present on a day-to-day basis in athletes or whether it is merely situational.

2. Methods

A sample of 283 elite Australian athletes (mean ± SD; age: 24 ± 5 y, age range: 16–47 y) volunteered to participate in the study from a variety of Australian sports (Tables 1 and 2). Athletes were recruited from the Australian Institute of Sport, Australian Winter Olympic team, Australian Paralympic team and National Sporting Organisations through personal contact with researchers or through coaching and/or support staff. All athletes were at an international level or were members of professional teams. The athletes sampled had competed in their sport for a mean of 11 ± 6 y, trained on average 16:42 ± 6:42 h per week, slept on average 7:42 ± 0:54 h per night and had competed in 14 ± 13 important competitions or games in the past 12 months (Table 2). Ethical approval was obtained through Murdoch University and the Australian Institute of Sport ethics committees prior to data collection.

In the period prior to (1 month) and following (7 months) the 2012 Olympic games, participants were asked to complete two questionnaires regarding their sleep (Competitive Sports and Sleep Questionnaire[6] and the Pittsburgh Sleep Quality Index[21]) either online (Survey Monkey©) or through hard copy.

The Competitive Sports and Sleep Questionnaire,[10] previously described by Erlacher and colleagues,[6] is a sport specific questionnaire used to assess sleep habits and dreams of athletes prior to important competitions and games. The questionnaire is divided into three main sections. The first section is used to obtain demographic data and information about the athlete's chosen sport. This information was used to categorise athletes into male and female, team sport or individual sport and in season or out of season at the time of answering the questionnaire, for statistical purposes. The subsequent section aimed to obtain information on athlete sleep habits prior to important competitions or games. If an athlete answered "yes" to having poor sleep at least once before an important competition or game in the past year, they were required to complete a further four closed response questions.

The initial closed response question assessed the types of sleep problems the athlete experienced. The response options were; "problems falling asleep", "waking up at night", "waking up early in the morning", and "unpleasant dreams" with the first three options referring to typical sleep problems associated with insomnia. The second question addressed reasons for the sleep disturbance; "not used to surroundings", "noises in the room or from outside", "nervousness about competition/game", and "thoughts about the competition/game". The third question addressed the perceived consequences of poor sleep with options including; "no influence", "bad mood the following day", "increased daytime sleepiness", and "poorer performance in competition". In the fourth question, athletes report on the strategies used to deal with sleeping problems with responses; "no special strategy", "methods to relax", "sleeping pills", "reading", and "watching TV".

In the final section of the questionnaire, an additional series of questions were used to obtain information regarding general sleep habits and training. Within this section athletes answered questions such as; "If you have a late training session or game do you find it hard to sleep after?" and "Do you take sleeping medication?".

The validated Pittsburgh Sleep Quality Index (PSQI) has been used throughout numerous sleep studies as a standardised sleep questionnaire estimating general sleep quality,[21] however there has been limited use in athletes.[16] For the current study the questionnaire was used to identify 'good' or 'poor' sleepers. Prior to filling out the PSQI athletes were notified that all answers were to indicate the most accurate reply for the majority of days and nights in the past month only. Seven component scores were generated (using a 0–3 scale): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. From the sum of the seven component scores a global score (range, 0–21) was calculated.[22,23] If an athlete scored between 0 and 5 they were classed as a 'good sleeper' as specified by the PSQI and a score above 5 classed an athlete as a 'poor sleeper'.[21]

Differences for age, years in sport, practice hours per week and sleep per night between the groups for gender, sport and time of season the questionnaire was answered were analysed using an independent sample *t*-test for the continuous variables. The percentage of athletes who responded "yes" to reporting poor sleep the night before an important competition or game in the past year was calculated. For the "yes" respondents, associations between categorical variables for sex (female versus male), sport groups (individual versus team sports) and time of season the questionnaire was answered (in season versus out of season) was calculated for each sleep disturbance question using a 2×2 frequency table and Pearson's chi-squared test (χ^2). To determine whether an association existed between athletes who reported "yes" or "no" to sleep disturbance prior to a competition and athletes who were classed as generally 'good' or 'poor' sleepers through the Pittsburgh Sleep Quality Index, a chi-squared test was calculated. A binary logistic generalised linear model was run to ascertain the effects of the dichotomised variables age, gender, sport and athletes in or out of season on the predicted likelihood of athletes having poor sleep prior to an important competition. All statistics were completed using SPSS© Statistics (version 19, IBM©, USA) and R (R Foundation for Statistical Computing, Vienna) statistical software programs with significance set to $p \leq 0.05$.

Please cite this article in press as: Juliff LE, et al. Understanding sleep disturbance in athletes prior to important competitions. *J Sci Med Sport* (2014), http://dx.doi.org/10.1016/j.jsams.2014.02.007

Table 2
Characteristics of athletes by gender, sport and season (mean ± SD).

	Overall (n = 283)	Gender		Sport		Season	
		Male (n = 126)	Female (n = 157)	Individual (n = 73)	Team (n = 210)	In-Season (n = 187)	Out of Season (n = 96)
Age	24.1 ± 5.1	24.0 ± 5.5	24.2 ± 4.9	24.4 ± 5.8	23.9 ± 4.9	24.5 ± 5.2*	23.2 ± 4.8
Years in sport	11 ± 6	11 ± 7	11 ± 6	11 ± 6.0	11 ± 7	11 ± 6	11 ± 6
Practice hours per week (h:min)	16:42 ± 6:42	16:42 ± 6:00	16:48 ± 7:12	23:00 ± 7:30*	14:36 ± 4:42	16:06 ± 6:06*	18:00 ± 7:30
Sleep duration per night (h:min)	7:42 ± 0:54	7:48 ± 0:54	7:36 ± 0:54	7:48 ± 1:00	7:36 ± 0:54	7:42 ± 0:54	7:42 ± 1:00

* Difference (p < 0.05) between groups within category.

3. Results

From the 283 Australian athletes sampled, 181 (64.0%) indicated they had slept worse than usual in the night(s) prior to an important competition or game over the past 12 months. There were no significant differences between gender (62.4% male vs. 65.9% female), sport (71.23% individual vs. 61.4% team) or athletes currently in or out of season (61.3% in-season vs. 69.1% out of season) (Table 3).

The 181 Australian athletes who reported worse sleep at least once prior to a competition or game answered further questions in relation to their sleep disturbances (Table 3). Overall, the majority of athletes indicated they had "problems falling asleep" (82.1%) due to "thoughts about the competition/game" (83.5%) however (46.6%) believed this had "no influence" on their performance.

There was an association between genders for unpleasant dreams, with dreams affecting sleep in females (10%) more frequently than males (0%); ($x^2_{(1)} = 9.16$, $p = 0.002$). In addition, females reported reading more frequently (32.6%) as a strategy to obtain improved sleep on the night prior to a competition than males (18.5%); ($x^2_{(1)} = 4.51$, $p = 0.034$). No further differences were found between gender.

There were no differences observed between individual versus team sport athletes for problems and reasons for sleep disturbance with both indicating internal factors "nervousness about the competition/game" and "thoughts about the competition/game" as the main reasons for their sleep disturbance (Table 3). An association ($x^2_{(1)} = 8.36$, $p = 0.005$) was found for individual athletes reporting worse sleep to have no influence on performance (63.5%) when compared with team sport athletes (39.7%). Increased daytime sleepiness was stated more frequently in team sport athletes (48.4%) compared with individual athletes (26.9%); ($x^2_{(1)} = 6.97$, $p = 0.012$). Additionally, a higher percentage of team sport athletes (59.1%) reported having no special strategy to obtain better sleep on the night before an important competition or game compared with individual athletes (32.7%); ($x^2_{(1)} = 9.87$, $p = 0.002$). Individual athletes reported using methods to relax ($x^2_{(1)} = 5.53$, $p = 0.024$) and reading ($x^2_{(1)} = 12.4$, $p = 0.001$) as strategies to enhance sleep more often than team sport athletes (Table 3).

There was an association between poor sleep responses prior to competition and the PSQI ($x^2_{(1)} = 5.195$, $p = 0.002$) indicating the two variables are statistically independent of one another.

The logistic regression model that predicted the likelihood participants had poor sleep was statistically significant ($x^2_{(3)} = 15.819$, $p = 0.001$). Of the four predictor variables, age, gender, sports and season, only two were statistically significant; age ($p = 0.019$) and sport ($p = 0.004$). Increasing age was associated with an increased probability of exhibiting poor sleep in individual sport athletes whereas team sport athletes' probability of poor sleep decreased with age (Fig. 1).

General sleep disturbance percentages indicate 52.5% of athletes experience poor sleep post late game whilst 47.5% show no sleep disturbance. Following a rest day 28.4% of athletes indicate having sleep disturbance whilst 71.6% did not. Finally 27.7% of athletes experience sleep disturbance during heavy training periods.

4. Discussion

The purpose of this study was to understand the sleep complaints of elite Australian athletes prior to important competitions and games. The main findings were (1) 64% of Australian athletes surveyed experienced sleep problems prior to a major competition at least once in the previous 12 months. The key sleep complaint reported was difficulty initiating sleep due to nervousness and thoughts prior to competition. (2) The perceived influence of poor sleep on performance varied between individual and team sport athletes. (3) When further examining individual and team sport variances, the percentage use of strategies was statistically different. (4) The predicted likelihood of sleep disturbance due to an athlete's age differed with individual and team sport athletes. (5) A novel finding was the sleep problems reported by athletes in this study were confined to competition periods only.

In the present study, we observed 64% of the athletes surveyed indicated sleep disturbance prior to important competition which supports previous anecdotal evidence. This finding is comparable to the occurrence of sleep complaints found in German athletes (65.8%) prior to major competitions.[6] The majority of Australian athletes who indicated experiencing worse sleep prior to competition reported internal factors as the main reason responsible (Table 3). Specifically, nervousness and thoughts about the

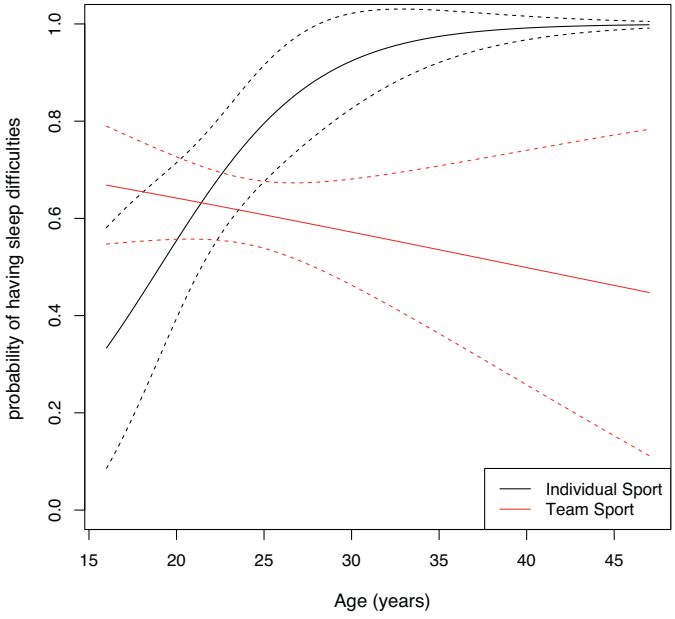

Fig. 1. The predicted probability of sleep difficulties prior to an important competition for individual and team sport athletes' based on age. Predicted probabilities and 95% confidence intervals are displayed.

Please cite this article in press as: Juliff LE, et al. Understanding sleep disturbance in athletes prior to important competitions. *J Sci Med Sport* (2014), http://dx.doi.org/10.1016/j.jsams.2014.02.007

Table 3
Absolute and relative number of responses for each person who states, "Yes" they have had disrupted or fragmented sleep prior to an important competition or game in the last 12 months.

	All Participants		Gender				Sport				Season			
	Absolute	Frequency (%)	Male (%)	Female (%)	Chi square	*p*-Value	Individual (%)	Team (%)	Chi square	*p*-Value	Out of season (%)	In season (%)	Chi square	*p*-Value
Overall	181	64.0	65.9	62.4	0.55	0.619	71.2	61.4	0.13	0.158	69.1	61.3	0.20	0.240
"**What kinds of problems did you experience with your sleep prior to an important competition or game?**" $n = 179$														
Problems falling asleep	147	82.1	80.7	83.3	0.21	0.698	80.7	82.7	0.09	0.831	86.2	79.8	1.13	0.318
Waking up early in the morning	48	26.8	24.1	29.2	0.58	0.501	32.7	24.4	1.29	0.269	24.6	28.1	0.25	0.726
Waking up at night	68	38.0	32.5	42.7	1.96	0.169	44.2	35.4	1.21	0.310	43.1	35.1	1.12	0.337
Unpleasant dreams	10	5.6	0	10	9.16	0.002*	4	6	0.42	0.726	6	5	0.06	1.000
Not feeling refreshed in morning	65	36.3	34.9	37.5	0.13	0.757	32.7	37.8	0.42	0.608	30.8	39.5	1.36	0.262
"**What reasons were responsible for your sleeping problems prior to an important competition or game?**" $n = 176$														
Thoughts about competition	147	83.5	82.9	84.0	0.16	0.837	76.5	86.4	2.59	0.120	83.1	83.8	0.01	1.000
Nervousness about competition	77	43.8	42.7	44.7	0.07	0.877	49.0	41.6	0.81	0.405	44.6	43.2	0.03	0.876
Not used to surroundings	39	22.2	23.3	22.3	0.02	1.000	21.6	23.3	0.05	1.000	26.2	20.7	0.69	0.458
Noises in room or outside	31	17.6	15.0	19.0	0.75	0.428	26.0	14.0	3.62	0.076	15.0	18.0	0.31	0.666
"**In what manner did the sleeping problems influence your performance during the competition or game?**" $n = 178$														
No influence	83	46.6	48.2	45.3	0.15	0.764	63.5	39.7	8.36	0.005*	56.9	40.7	4.36	0.043*
Increased daytime sleepiness	75	42.1	36.1	47.4	2.29	0.171	26.9	48.4	6.97	0.012*	35.4	46.0	1.91	0.207
Bad mood the following day	24	13.4	13.3	13.7	0.01	1.000	11.5	14.3	0.24	0.810	4.6	18.6	6.90	0.011*
Worse performance in competition	25	14.0	17.0	12.0	1.03	0.388	17.0	13.0	0.65	0.478	11.0	16.0	0.91	0.380
"**Which strategies did you use to sleep well in the nights preceding a competition?**" $n = 176$														
No Strategy	91	51.7	54.3	49.5	0.41	0.548	32.7	59.1	9.87	0.002*	48.4	53.6	0.43	0.534
Methods to relax	37	21.0	22.2	20.0	0.13	0.853	32.3	16.5	5.53	0.024*	20.3	21.6	0.03	1.000
Sleeping pills	23	13.1	12.3	13.7	0.07	0.826	12.2	13.4	0.04	1.000	15.6	11.6	0.58	0.490
Reading	46	26.1	18.5	32.6	4.51	0.034*	44.9	18.9	12.4	0.001*	29.7	24.1	0.66	0.477
Watching TV	34	19.3	22.2	16.8	0.81	0.445	25.5	16.5	2.27	0.141	20.3	18.8	0.06	0.844

* Association ($p < 0.05$) between groups within a category.

Please cite this article in press as: Juliff LE, et al. Understanding sleep disturbance in athletes prior to important competitions. *J Sci Med Sport* (2014), http://dx.doi.org/10.1016/j.jsams.2014.02.007

competition were the most common reasons for sleep problems regardless of an athlete's gender or sport. This finding is consistent with previous research in both marathon runners[7] and German athletes[6] who reported experiencing anxiety and excessive thoughts prior to competition. Whilst external factors such as noise may impact sleep, our results confirm internal factors strongly influence sleep disturbance in the current athlete population.

Consequences of fragmented sleep on performance are of importance to athletes and coaches, as sleep restriction whether chronic or acute may have detrimental effects on health and performance.[24] In our study, the two most commonly reported consequences of sleep disruption were (1) no perceived influence on performance (46.6%) and/or (2) increased daytime sleepiness (42.1%). The later finding is consistent with previous studies in athletes[6] and the general population[24] where daytime sleepiness was recognised as the most frequently described consequence of insufficient sleep. Interestingly, only 14% of all surveyed athletes believed reduced sleep directly resulted in worse performance during competition. Performance was not assessed during the study therefore there is little information to determine whether an athlete had an accurate perception of performance impacts.

Results indicate individual sport athletes are similar to team sport athletes in the reported occurrence of sleep complaints prior to major competitions. These findings contrast those by Erlacher et al.[6] who observed greater reporting of poor sleep in individual sport athletes compared with team sport athletes. This difference was explained by the lower pressure and anxiety experienced in team sports as these athletes, unlike individual sport athletes, are not solely responsible and accountable for their own results.[6] Although this explanation is feasible our data does not support this hypothesis as we observed team sport athletes to report nervousness and thoughts prior to competition as reasons responsible for the poor sleep similar to the individual athletes. While additional research is needed to examine differences in sleep habits of individual versus team sport athletes to fully appreciate the diversity, our current data indicates sleep education through methods such as sleep hygiene (behaviours that are believed to promote improved quantity and quality of sleep[25]) could provide benefits of sleep enhancement in both individual and team sport athletes.

Despite team and individual sport athletes reporting similar sleep problems and reasons responsible for sleep disturbance, team sport athletes reported a greater incidence of daytime sleepiness compared with individual sport athletes (Table 3). It is possible the greater daytime sleepiness in team sport athletes is due to a lack of sleep strategies utilised to overcome sleep complaints compared with individual sport athletes (Table 3). For instance, individual sport athletes reported more frequently the reliance on reading and/or methods to relax to combat sleep complaints in comparison with team sports athletes who were more likely to have no strategies in place (Table 3). Furthermore, as individual athletes indicated having a greater number of strategies to overcome sleep disturbance this possibly explains why these athletes reported sleeping problems to have little influence on their performance more frequently than their team sport counterparts.

Increasing age in individual sport athletes was associated with an increased likelihood of sleep disturbance prior to competition. Intuitively it could be hypothesised that sleep quality before competition would improve as an athlete aged due to being accustomed to the experience of competition however this does not seem to be the case. Defining normal sleep in athletes and differing age categories remains a challenge due to multiple factors contributing to poor sleep.[26] Indeed, age related differences in sleep have been documented; however, these changes are most prominent in individuals beyond 40 years of age thus, limiting the usefulness of this data in our athlete population.[27] The exact reason for the increased likelihood of sleep disturbance in individual sport athletes as they age remains unknown and warrants further investigation.

Interestingly, a lack of association was observed between athletes who reported poor sleep prior to competition, from the Competitive Sports and Sleep Questionnaire and whether the athlete was classed as a "poor" sleeper in general, as determined by the Pittsburgh Sleep Quality Index. This finding implies that although an athlete may not be classed as a problematic sleeper on a day-to-day basis, sleep complaints may arise around competition periods that otherwise are not present. Indeed, in our athletes more than half reported sleep disturbance following a late game or training session. In addition, a smaller number indicated fragmented sleep following heavy training periods and days of rest. These findings highlight the need for caution when using a single subjective sleep quality questionnaire to assess an athletic population, as global sleep quality assessments may not display the same efficacy as with the general population, due to situational stressors and events athletes' encounter.

5. Conclusion

Our findings highlight the majority of Australian athletes' surveyed subjectively indicated sub-optimal sleep surrounding important competitions mainly due to nervousness and thoughts prior to competition. With evidence suggesting athletes sleep poorly pre-competition more research is needed to investigate the effects of acute sleep loss on athletic performance. The current sleep strategy results were concerning with few athletes aware of sleep strategies to utilise during these critical competition periods. Whilst no gender differences were exhibited, there were age and team sport versus individual sport differences that should be considered. The poor sleep reported during competition appears to be situational and not associated with poor sleep in general. The current study highlights the need for individual monitoring of athlete sleep habits and the need for increased sleep hygiene education within both individual and team sports.

Practical implications

- Both team sport and individual sport athletes would benefit from sleep education.
- Athletes should be made aware and educated on strategies such as sleep hygiene to assist them to sleep around important competitions.
- Sleep strategies should specifically focus on combatting nervousness and thoughts prior to competition in athletes.

Conflict of interest

No competing agreements, professional relationships and financial interests existed where a third party may benefit from the presented results.

Acknowledgements

The authors would like to thank all athletes involved in the study. The authors also would like to express gratitude to Dr. Emma Knight and Ian Rayson for their statistical assistance.

References

1. Davison RCR, Williams AM. The use of sports science in preparation for Olympic competition. *J Sports Sci* 2009; 27(3):1363–1365.
2. Vaile J, Halson S, Graham S. Recovery review – science vs practice. *J Aust Strength Cond* 2010; 18(Suppl. 2):5–21.

Please cite this article in press as: Juliff LE, et al. Understanding sleep disturbance in athletes prior to important competitions. *J Sci Med Sport* (2014), http://dx.doi.org/10.1016/j.jsams.2014.02.007

3. Leeder J, Glaister M, Pizzoferro K et al. Sleep duration and quality in elite athletes measured using wristwatch actigraphy. *J Sports Sci* 2012; 30(6):541–545.
4. Halson SL. Nutrition, sleep and recovery. *Eur J Sport Sci* 2008; 8(2):119–126.
5. Halson SL. Sleep and the elite athlete. *Sports Sci* 2013; 26(113):1–4.
6. Erlacher D, Ehrlenspiel F, Adegbesan OA et al. Sleep habits in German athletes before important competitions or games. *J Sports Sci* 2011; 29(8): 859–866.
7. Lastella M, Lovell GP, Sargent C. Athletes' precompetitive sleep behaviour and its relationship with subsequent precompetitive mood and performance. *Eur J Sport Sci* 2012:1–8 [ahead-of-print].
8. Cook CJ, Crewther BT, Kilduff LP et al. Skill execution and sleep deprivation: effects of acute caffeine or creatine supplementation—a randomized placebo-controlled trial. *J Int Soc Sports Nutr* 2011; 8(2):1–8.
9. Waterhouse J, Atkinson G, Edwards B et al. The role of a short post-lunch nap in improving cognitive, motor, and sprint performance in participants with partial sleep deprivation. *J Sports Sci* 2007; 25(14):1557–1566.
10. Skein M, Duffield R, Edge J et al. Intermittent-sprint performance and muscle glycogen after 30 h of sleep deprivation. *Med Sci Sports Exerc* 2011; 43:1301–1311.
11. Oliver SJ, Costa RJ, Laing SJ et al. One night of sleep deprivation decreases treadmill endurance performance. *Eur J Appl Physiol* 2009; 107(2):155–161.
12. Taheri M, Arabameri E. The effect of sleep deprivation on choice reaction time and anaerobic power of college student athletes. *Asian J Sports Med* 2012; 3(1):15–20.
13. Abedelmalek S, Chtourou H, Aloui A et al. Effect of time of day and partial sleep deprivation on plasma concentrations of IL-6 during a short-term maximal performance. *Eur J Appl Physiol* 2013; 113(1):241–248.
14. Underwood J. Sleep now clearly a predictor of performance. *Coaches Plan* 2010; 17(1):31–34.
15. Blumert PA, Crum AJ, Ernsting M et al. The acute effects of twenty-four hours of sleep loss on the performance of nationalcaliber male collegiate weightlifters. *J Strength Cond Res* 2007; 21(4):1146–1154.
16. McMorris T, Graydon J. The effect of exercise on cognitive performance in soccer-specific tests. *J Sports Sci* 1997; 15(5):459–468.
17. Davenne D. Sleep of athletes-problems and possible solutions. *Biol Rhythm Res* 2009; 40(1):45–52.
19. Samuels C. Sleep, recovery, and performance: the new frontier in high-performance athletics. *Phys Med Rehabil Clin N Am* 2009; 20(1):149–159.
20. Driver HS, Rogers GG, Mitchell D et al. Prolonged endurance exercise and sleep disruption. *Med Sci Sports Exerc* 1994; 26(7):903–907.
21. Buysse DJ, Reynolds CF, Monk TH et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989; 28(2):193–213.
22. King AC, Oman RF, Brassington GS et al. Moderate-intensity exercise and self-rated quality of sleep in older adults. A randomized controlled trial. *J Am Med Assoc* 1997; 277(1):32–37.
23. King AC, Pruitt LA, Woo S et al. Effects of moderate-intensity exercise on polysomnographic and subjective sleep quality in older adults with mild to moderate sleep complaints. *J Gerontol A Biol Sci Med Sci* 2008; 63(9):997–1004.
24. Goel N, Rao H, Durmer JS et al. Neurocognitive consequences of sleep deprivation. *Semin Neurol* 2009; 29:320–339. NIH Public Access.
25. Stepanski EJ, Wyatt JK. Use of sleep hygiene in the treatment of insomnia. *Sleep Med Rev* 2003; 7(3):215–225.
26. Dijk DJ, Archer SN. PERIOD3, circadian phenotypes, and sleep homeostasis. *Sleep Med Rev* 2010; 14(3):151–160.
27. Van Cauter E, Leproult R, Plat L. Age-related changes in slow wave sleep and REM sleep and relationship with growth hormone and cortisol levels in healthy men. *J Am Med Assoc* 2000; 284(7):861–868.

Please cite this article in press as: Juliff LE, et al. Understanding sleep disturbance in athletes prior to important competitions. *J Sci Med Sport* (2014), http://dx.doi.org/10.1016/j.jsams.2014.02.007