Article published online: 2023-10-13

ORIGINAL ARTICLE

Sleep Science

Development of the athlete sleep behavior questionnaire: A tool for identifying maladaptive sleep practices in elite athletes

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Received: November 1, 2017; Accepted: January 30, 2018.

DOI: 10.5935/1984-0063.20180009

ABSTRACT

Introduction: Existing sleep questionnaires to assess sleep behaviors may not be sensitive in determining the unique sleep challenges faced by elite athletes. The purpose of the current study was to develop and validate the Athlete Sleep Behavior Questionnaire (ASBQ) to be used as a practical tool for support staff working with elite athletes. **Methods:** 564 participants (242 athletes, 322 non-athletes) completed the 18-item ASBQ and three previously validated questionnaires; the Sleep Hygiene Index (SHI), the Epworth Sleepiness Scale (ESS) and the Pittsburgh Sleep Quality Index (PSQI). A cohort of the studied population performed the ASBQ twice in one week to assess test-retest reliability, and also performed sleep monitoring via wrist-actigraphy. **Results:** Comparison of the ASBQ with existing sleep questionnaires resulted in *moderate* to *large* correlations (r=0.32 - 0.69). There was a significant difference between athletes and non-athletes for the ASBQ global score (44±6 *vs*. 41±6, respectively, p<0.01) and for the PSQI, but not for the SHI or the ESS. The reliability of the ASBQ was acceptable (ICC=0.87) when re-tested within 7 days. There was a *moderate* relationship between ASBQ and total sleep time (r=-0.42). **Conclusion:** The ASBQ is a valid and reliable tool that can differentiate the sleep practices between athletes and non-athletes, and offers a practical instrument for practitioners and/or researchers wanting to evaluate the sleep behaviors of elite athletes. The ASBQ may provide information on areas where improvements to individual athletes' sleep habits could be made.

Keywords: Surveys and Questionnaires; Actigraphy; Polysomnography; Sleep Hygiene; Athletes.

INTRODUCTION

There is increasing recognition that sleep plays a significant role in aiding the recovery process in highly-trained athletes[1-3]. According to Halson[4] and Leeder et al.[5], sleep is reported to be the single best psycho-physiological recovery strategy available to elite athletes. Therefore, the quantification and measurement of sleep amongst athletic populations has become commonplace in the sport setting[6]. Objective methods of measuring sleep such as polysomnography and actigraphy require a somewhat intrusive and expensive assessment of sleep, coupled with the need for specialized expertise, making them difficult to administer across large numbers of athletes. Different questionnaires and scales used for surveying sleep have been validated in the literature, with little focus on athlete-specific measures. Indeed, research has shown that athletes may display different sleeping patterns and habits compared to the non-athlete population[5,7-9], likely due to the unique physiological and psychological demands of being an elite athlete.

It has been reported that sleep may be compromised in elite athletes due to a number of factors, including the increase in core temperature following exercise[10], increases in muscle tension, fatigue and pain following training and competition[11,12], frequent international travel[13], disruption from light and noise and increases in psychological stress[14]. Juliff et al.[7] reported from 283 elite athletes, that 64% of athletes reported sleep disturbances due to nervousness or over-thinking before competition and more than half of the sample suffered sleep disturbances following a late training session or competition. Other sleep disturbances that seem to be magnified in elite athletes include the use of long naps in the afternoon interrupting night-time sleep, the use of stimulants (e.g. caffeine), frequent travel, sleeping in different environments (e.g. hotels), and either over-hydration or dehydration prior to bed[14-16]. Existing surveys, scales and questionnaires that evaluate sleep behavior in the general population may not be specific enough to detect these unique differences in an athlete's sleeping patterns and habits.

A plethora of sleep questionnaires have been evaluated in the research literature. Some of these include the Pittsburgh Sleep Quality Index[17], the Sleep Hygiene Index[18], and the Epworth Sleepiness Scale[19]. While these questionnaires and scales may be appropriate for general or clinical populations, they lack specific questions that are tailored towards the sleep challenges faced by elite athletes.

To our knowledge, the only athlete-specific sleep questionnaire in the literature is the Athlete Sleep Screening Questionnaire (ASSQ)[20]. The ASSQ was designed to provide clinical screening with cut-off scores associated with the specific clinical interventions to manage sleep disorders. While initial reports of the ASSQ have shown that it is a valid tool in screening athletes for sleep disturbances, there remains a need for an instrument that can provide useful information on the sleep behavior practices of elite athletes, allowing for individualized feedback and behavioral modifications based on their responses. Indeed, recent research has shown that improvements in sleep can be achieved in elite athletes, through simple sleep-behavior education and subsequent changes in maladaptive habits[21].

Therefore, the purpose of the current study was to develop an athlete-specific sleep questionnaire and validate it against both objective (wrist-actigraphy) and subjective (validated questionnaires) sleep measures in both athletes and non-athletes. A further aim of the study was to determine the test-retest reliability of the questionnaire.

METHODS

Participants

The survey was completed by a convenience sample of 564 participants (282 male/282 female, mean±SD, age; 25±7 y) across 9 countries (Australia, Canada, England, India, Malaysia, New Zealand, Portugal, Sweden, USA). The study population was divided into athletes (n=242) and non-athletes (n=322) for analysis (Table 1). All participants for both groups were aged between 18-45 y at the time of taking part in the study. New parents (children <2 y) and individuals with diagnosed sleep disorders were excluded from taking part in the study.

Table 1. Participant demographics.

	Athletes (n=242)	Non-athletes (n=322)
Age (y)	22±5	25±6
Male (n=)	87	195
Female (n=)	155	127
Team sport (n=)	128	N/A
Individual sport (n=)	114	

The criteria for the 'athlete' population used in the current study was: representation of their country at either national or international-level (semi-professional or professional) for their chosen sport. Athletes were surveyed across 18 different sports (team sport athletes = 128 and individual sport athletes = 114) and completed the survey during the in-season phase of their training (minimum of 4-weeks into their competition season). Athletes from the following sports were surveyed: badminton (n=8), baseball (n=9), basketball (n=15), boxing (n=5), cricket (n=10), cycling (n=15), football/soccer (n=12), golf (n=10), hockey (n=18), netball (n=19), rowing (n=17), rugby league (n=14), rugby union (n=24), swimming (n=14), track and field (n=26), tennis (n=6), triathlon (n=13) and water-polo (n=7).

The criteria for the 'non-athlete' population included participants that; a) were not members of any regional or national-level sporting team, and b) were performing ≤3 planned exercise training sessions per week. The 'non-athlete' population was a random selection of participants also surveyed from the 9 aforementioned countries. All participants were recruited via National Sporting Organisations, various social media channels and word-of-mouth advertising. The questionnaire was not translated into any other languages, and therefore it was a requirement that all participants were fluent English speakers. The study was approved by the Institutions Human Research Ethics Committee (Ethics number: FEDU066/16) and as outlined to participants, by completing the survey, informed consent to take part in the study was given.

Instruments

The following four sleep questionnaires were administered to all participants via an electronic online survey (Survey Monkey, Palo Alto Inc. CA, USA). All four questionnaires were filled out in a single sitting and average time to complete the questionnaires was 8.5 minutes. On average, the ASBQ took 1.5 minutes to complete. All questionnaires asked participants to answer the questions relating to their normal sleeping patterns over the previous month.

The Athlete Sleep Behavior Questionnaire (ASBQ)

The ASBQ is the survey that has been specifically designed for evaluation in the current study. A combination of the Sleep Hygiene Index[18], the International Classification of Sleep Disorders[22], and previous research describing the most common sleep issues in elite athletes[7,23] and recommended tips and strategies to address these issues[10,15,21] was used to develop the ASBQ. The ASBQ is an 18-item survey that includes questions on sleeping behavior and habits thought to be common areas of concern for elite athletes (Table 2) and was designed as a practical tool to identify areas where improvements in sleep behavior could be made, rather than a clinical screening tool. The survey asks participants how frequently they engage in specific behaviors (never, rarely, sometimes, frequently, always). Weightings for each response (1 = never, 2 = rarely, 3 = sometimes, 4 = frequently, 5 = always) were summed to provide an ASBQ global score. A higher global score is indicative of poor sleep behaviors.

The Sleep Hygiene Index (SHI)

The SHI is a 13-item self-administered index intended to assess the presence of behaviors thought to comprise sleep hygiene. Participants are asked to indicate how frequently they engage in specific behaviors (always, frequently, sometimes, rarely, never). Item scores were then summed providing a global score for sleep hygiene. Higher scores are indicative of more maladaptive sleep hygiene status. The SHI has been shown to be both valid and reliable in a healthy population[18].

Epworth Sleepiness Scale (ESS)

The Epworth Sleepiness Scale (ESS) is a self-reported 8-item questionnaire that produces a global score from 0-24. Scores greater than 10 suggest significant daytime sleepiness[19]. The ESS is commonly used to differentiate between individuals with and without sleep disorders and has also shown to correlate with objective measures of sleepiness[24].

The Pittsburgh Sleep Quality Index (PSQI)

The PSQI is a self-rated 19-item instrument intended to assess sleep quality and sleep disturbance over a 1-month period in clinical and nonclinical populations[25]. Global scores range from 0 to 21 with higher scores indicating poorer overall sleep quality. The PSQI has been demonstrated to have good internal reliability, validity and is perhaps the most commonly-used subjective sleep measure not only in the research literature, but also in the sleep community[25].

Reliability

The test-retest reliability and sleep-monitoring component of the study was completed by 50 participants (27 male/23 female, 19 team sport athletes/31 individual athletes, mean ± SD; age: 23±5 y) from the athlete cohort. Athletes were randomly selected and the following sports were included in the reliability (and actigraphy) analysis: cycling (n=7), football (n=3), netball (n=9), rugby league (n=7), rowing (n=10), swimming (n=4), track and field (n=10). All participants completed the ASBQ two times separated by exactly 7 days. The test was performed at the same time of day on both occasions and took place during an in-season, non-competitive week. The day that the ASBQ was filled out on both occasions was preceded by a rest day, where no athletic training or competition was performed. The reliability component of the current study was assessed concurrently with the measurement of sleep through wrist-actigraphy.

Actigraphy

A total of 50 athletes from the current study (same cohort as described in the reliability component above) wore a wrist activity monitor to evaluate their sleeping patterns. Participants were required to wear the activity monitor (SBV2 Readiband™, Fatigue Science, Honolulu, USA), continuously over a 7-day period with the exception of time spent in water, bathing or showering. Participants were instructed to maintain their usual sleep habits and general daily activity patterns during the monitoring period.

Sleep indices used for comparison to the ASBQ global score were: total time in bed, total sleep time, sleep efficiency and sleep latency. Each morning during the monitoring period, athletes were also asked to rate their perceived sleep quality on a scale from 1-5 (1 = very poor, 5 = excellent). Participants were also asked to record their sleep and wake times in a diary, to allow for cross-checking and corrections with the actigraphy data. The accuracy and inter-device reliability of the Readiband device has been deemed acceptable, as described elsewhere[26,27].

Statistical Analysis

Descriptive statistics are shown as means ± SD unless stated otherwise. Statistical analysis was performed using SPSS V22.2 (IBM Corporation; Chicago, IL, USA). Comparison of athletes to non-athletes were performed for each questionnaire and each item of the ASBQ using independent samples t-tests, with statistical significance set at $p<0.05$. There were no outliers in the data, as assessed by inspection of a boxplot. Global scores for each questionnaire and each item of the ASBQ were normally distributed, as assessed by Shapiro-Wilk's test ($p>0.05$), and there was homogeneity of variances between groups, as assessed by Levene's test for equality of variances ($p>0.05$). Cohen's effect

Table 2. The Athlete Sleep Behavior Questionnaire (ASBQ).

No.	In recent times (over the last month)…	Never	Rarely	Sometimes	Frequently	Always
1	I take afternoon naps lasting two or more hours					
2	I use stimulants when I train/compete (e.g caffeine)					
3	I exercise (train or compete) late at night (after 7pm)					
4	I consume alcohol within 4 hours of going to bed					
5	I go to bed at different times each night (more than ±1 hour variation)					
6	I go to bed feeling thirsty					
7	I go to bed with sore muscles					
8	I use light-emitting technology in the hour leading up to bedtime (e.g laptop, phone, television, video games)					
9	I think, plan and worry about my sporting performance when I am in bed					
10	I think, plan and worry about issues not related to my sport when I am in bed					
11	I use sleeping pills/tablets to help me sleep					
12	I wake to go to the bathroom more than once per night					
13	I wake myself and/or my bed partner with my snoring					
14	I wake myself and/or my bed partner with my muscle twitching					
15	I get up at different times each morning (more than ±1 hour variation)					
16	At home, I sleep in a less than ideal environment (e.g too light, too noisy, uncomfortable bed/pillow, too hot/cold)					
17	I sleep in foreign environments (e.g hotel rooms)					
18	Travel gets in the way of building a consistent sleep-wake routine					

Scoring:
Never = 1, Rarely = 2, Sometimes = 3, Frequently = 4, Always = 5   Total Global Score: _________

sizes (*d*) were calculated between athletes and non-athletes for each questionnaire and interpreted using thresholds of 0.2, 0.5, 0.8 for *small, moderate* and *large*, respectively[28]. Comparison of the previously validated sleep questionnaire global scores and the ASBQ global score was achieved with Pearson product-moment correlation analysis for the entire sample (n=564).

Correlation between the ASBQ and measured sleep variables were also assessed in a cohort of the study population (n=50). The magnitude of correlation between the ASBQ and the other questionnaires/sleep measures was assessed using the following thresholds: <0.1, *trivial*; 0.1-0.3, *small*; 0.3-0.5, *moderate*; 0.5-0.7, *large*; 0.7-0.9, *very large*; and 0.9-1.0, *almost perfect*. Test-retest reliability of the ASBQ were analyzed using an Excel spreadsheet for reliability[29] with data shown as intra-class correlation coefficients (ICC), Pearson correlations (*r*), typical error of measurement (TEM) and coefficient of variation percentage (CV%).

Internal reliability/consistency of the ASBQ was determined using Cronbach's α. A principal component analysis (PCA) was run on the 18-item questionnaire and the suitability of the PCA was assessed prior to analysis via the Kaiser-Meyer-Olkin measure and the Bartlett's test of sphericity[30]. Exploratory factor analysis using PCA with a varimax rotation was used to extract three underlying dimensions of the questionnaire. PCA revealed that the three factors that had eigenvalues greater than one and visual inspection of the scree plot confirmed that three components should be retained31. Interpretation of these three components was consistent with themes of routine/environmental related factors for factor 1, behavioral factors for factor 2 and sport-related factors for factor 3 (Table 6).

RESULTS

There were no significant differences between male and female participants for the ASBQ global score within either athlete (p=0.20) or non-athlete groups (p=0.21), nor were there differences for team vs. individual sport athletes (p=0.69), therefore, both the athlete group and non-athlete groups were pooled for comparison with each other.

There was a significant difference between athlete and non-athlete groups for the ASBQ global score (43.5 and 40.6, respectively, p<0.01, d=0.47, Table 3), which included a significant difference between groups in 10 of the 18 items in the questionnaire (Figure 1). There were no significant differences between groups for the SHI or the ESS and both associated with *trivial* effect sizes (Table 3). The PSQI global score was significantly higher in the non-athlete group (p<0.01, d=0.36, Table 3).

Table 3. Global scores for the four sleep questionnaires between athletes and non-athletes including *p*-values and effect-size comparisons between groups. Data shown as means ± SD.

	Athletes (mean ± SD)	Non-Athletes (mean ± SD)	Raw Difference (Non-Athlete - Athlete)	*p*-value	Effect-Size *d*
ASBQ	43.5±5.8	40.6±6.1	-2.9	<0.01	0.47 *Small*
SHI	32.3±6.1	32.4±6.4	0.1	0.81	0.02 *Trivial*
ESS	5.7±3.4	5.2±3.3	-0.6	0.06	0.18 *Trivial*
PSQI	5.1±2.5	6.1±2.9	1.0	<0.01	0.36 *Small*

ASBQ = Athlete Sleep Behavior Questionnaire; SHI = Sleep Hygiene Index; ESS = Epworth Sleepiness Scale; PSQI = Pittsburgh Sleep Quality Index.

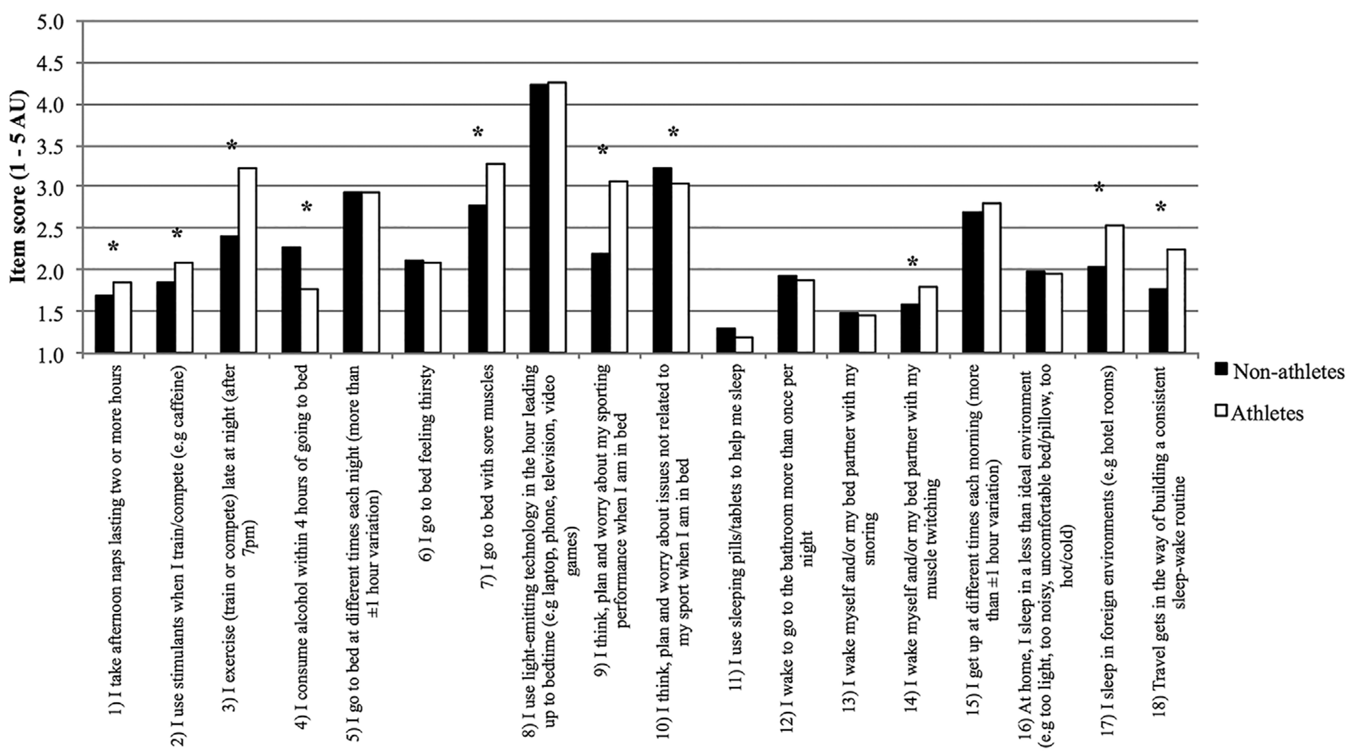

Figure 1. Legenda: Mean scores (out of 5) for Non-athletes (n=322, black bar) and Athletes (n=242, white bar) for each item of the 18-question Athlete Sleep Behavior Questionnaire (ASBQ). * Indicates significant difference between groups (p<0.05).

The ASBQ was shown to have *moderate* to *large* correlations with the existing validated sleep questionnaires (r=0.38 – 0.69, Table 4). The correlation between the ASBQ and objective sleep indices resulted in a *small* relationship for total time in bed and sleep efficiency (r=-0.18, -0.16, respectively), a *moderate* relationship for total sleep time and sleep quality (r=-0.42, -0.39, respectively) and a *trivial* correlation for sleep latency (r=0.07, Table 4).

The ASBQ resulted in acceptable levels of reliability (ICC=0.87, r=0.88, TEM = 2.3 AU, CV = 6.4%) when tested twice in one week (Table 5). The mean difference between test one and two was just 0.1±3.2 AU (Table 5). The internal consistency of the ASBQ resulted in a Cronbach's α of 0.63. The PCA factoring for the three-factor structure was performed with varimax rotation, which collectively accounted for 69.6% of the variance. The factor matrix showed that every item-factor loading was above the criterion of 0.45. Item loadings ranged from 0.45 to 0.61 (Table 6).

The sleep monitoring period in a cohort of the athlete population (n=50) used for correlation to the ASBQ resulted in the following mean ± SD values: total time in bed = 552±61 mins, total sleep time = 441±38 mins, sleep efficiency = 85±8%, sleep latency = 38±20 mins and subjective sleep quality = 3.7±0.6.

DISCUSSION

The results from the current study would support the use of the proposed 18-item Athlete Sleep Behavior Questionnaire for use as a practical tool for identifying maladaptive sleep practices in elite athletes. The ASBQ was a valid measurement tool

Table 4. Pearson's correlation coefficient (r) between the ASBQ global score and the three other questionnaires (n=564 participants) and between the ASBQ and sleep indices as measured by wrist-actigraphy (n=50 participants).

	SHI	ESS	PSQI	Total Time in Bed (mins)	Total Sleep Time (mins)	Sleep Efficiency %	Sleep Latency (mins)	Sleep Quality (1 - 5 AU)
ASBQ	0.69 *Large*	0.32 *Moderate*	0.38 *Moderate*	-0.18 *Small*	-0.42 *Moderate*	-0.16 *Small*	0.07 *Trivial*	-0.39 *Moderate*

ASBQ = Athlete Sleep Behavior Questionnaire; SHI = Sleep Hygiene Index; ESS = Epworth Sleepiness Scale; PSQI = Pittsburgh Sleep Quality Index; AU = Arbitrary Units.

Table 5. Test-retest reliability of the Athlete Sleep Behavior Questionnaire (n=50) when performed twice over 7-days. Mean data shown along with intra-class correlation coefficients (ICC), coefficient of variation % (CV%) and typical error of measurement (TEM), with 90% confidence intervals (90% CI).

	Test 1 (mean±SD)	Test 2 (mean±SD)	Raw Difference (mean±SD)	*r* (90% CI)	ICC (90% CI)	TEM (90% CI)	CV% (90% CI)
ASBQ Global Score	38.6±6.6	38.7±5.6	0.1±3.2	0.88 (0.81-0.92)	0.87 (0.80-0.92)	2.3 (2.0-2.7)	6.4 (5.4-7.7)

Table 6. Factor loadings for the Athlete Sleep Behavior Questionnaire as determined via Principal Component Analysis with a varimax rotation method.

ASBQ items	Factor loading
Factor 1 - Routine/environmental factors	
Q1. I take afternoon naps lasting two or more hours	0.52
Q5. I go to bed at different times each night (more than ±1 hour variation)	0.45
Q15. I get up at different times each morning (more than ±1 hour variation)	0.48
Q16. At home, I sleep in a less than ideal environment (e.g too light, too noisy, uncomfortable bed/pillow, too hot/cold)	0.51
Q17. I sleep in foreign environments (e.g hotel rooms)	0.43
Q18. Travel gets in the way of building a consistent sleep-wake routine	0.55
Factor 2 - Behavioral factors	
Q2. I use stimulants when I train/compete (e.g caffeine)	0.58
Q4. I consume alcohol within 4 hours of going to bed	0.48
Q8. I use light-emitting technology in the hour leading up to bedtime (e.g laptop, phone, television, video games)	0.47
Q10. I think, plan and worry about issues not related to my sport when I am in bed	0.61
Q11. I use sleeping pills/tablets to help me sleep	0.56
Q12. I wake to go to the bathroom more than once per night	0.56
Q13. I wake myself and/or my bed partner with my snoring	0.48
Factor 3 - Sport-related factors	
Q3. I exercise (train or compete) late at night (after 7pm)	0.49
Q6. I go to bed feeling thirsty	0.57
Q7. I go to bed with sore muscles	0.45
Q9. I think, plan and worry about my sporting performance when I am in bed	0.53
Q14. I wake myself and/or my bed partner with my muscle twitching	0.45

when compared to three other established sleep questionnaires and was sensitive enough to determine the difference in sleep behavior scores in athletes when compared to non-athletes. The ASBQ was shown to have high levels of test-retest reliability, further supporting its use in both research and practical settings. When compared to sleep monitoring via wrist-actigraphy, in a cohort of the studied population, the ASBQ displayed a *moderate* relationship with one of the key sleep measures, total sleep time. We would suggest that the ASBQ is a useful tool to identify the sleep behaviors of elite athletes.

Perhaps one of the pertinent issues with the existing sleep questionnaires, is their inability to adequately differentiate the unique sleep problems faced by elite athletes. Indeed, the current study would support this, as evidenced through the non-significant differences and *trivial* effect sizes for athletes vs. non-athletes in the SHI and ESS global scores ($p>0.05$, Table 3). While there was a significant difference between groups for the PSQI, this was actually in favor of the athlete group, suggesting that sleep quality may be higher in athletes vs. non-athletes, which is in direct contrast to previous literature[5,23,32].

Even though both groups can be classified as "poor sleepers" according to the PSQI threshold of >5, it is still important to speculate why non-athletes had a higher global PSQI score. This may be explained by evaluating the individual components of the PSQI, where there was a significant difference for athletes compared to non-athletes for one component of the questionnaire. Component #4 refers to sleep efficiency (time spent sleeping divided by time spent in bed). While total sleep time between groups was similar, non-athletes had lower sleep efficiency, due to longer time spent in bed (531±96 minutes) when compared to the athlete group (519±104 minutes). When comparing the ASBQ between the athlete and non-athlete populations, results showed that the scores for 10 out of the 18 items/questions were significantly greater in the athlete group, indicating poorer sleep behaviors (Figure 1).

While there were no significant differences between groups for the 8 remaining items, the authors would suggest that these are still valuable questions for gaining specific information on the habits of individual athletes, based on previous recommendations[15]. As identified by Juliff et al.[7], one of the major challenges for athletes was problems falling asleep due to their thoughts about competition. The current study would support this, with one of the highest ratings by athletes (indicative of a challenge to sleep) in question #9 - "I think, plan and worry about my sporting performance when I am in bed" (Figure 1). Other questions with the highest ratings by athletes in the current study were question #7 - "I go to bed with sore muscles" and question #2 - "I exercise late at night" (Figure 1).

The test-retest reliability of the ASBQ was very high, with a mean difference of only 0.1 on the global score between the two tests (Table 5). This difference was associated with an *r* value of 0.88, an ICC of 0.87, a TEM of 2.3 and a CV of 6.4%. In contrast to the other scales used in the current study, our results would suggest that the ASBQ is comparable, or even more reliable in a test-retest setting. Authors reported an *r* value of 0.71 when evaluating the SHI in a test-retest trial, with 4 weeks between each test[18]. The original study to develop the PSQI reported a test-retest correlation of r=0.85[25], however, the time duration between tests is somewhat unclear, with an average of 28.2 days reported, but the specified range was 1 - 265 days. The ESS, when administered to 87 healthy students twice in 5 months, resulted in a test-retest *r* value of 0.82[33]. Unfortunately, the differing range of methodologies implemented between studies make it difficult to draw comparisons with the reliability of the ASBQ in the current study.

A potential limitation of the current study was the relatively short (one week) test-retest time frame for assessing the reliability of the ASBQ. However, given the ASBQ asks for the participants' normal habits over the previous month, the authors felt that if a period of one month or more was used, the reliability of the tool may be compromised, not because of the tool itself, but because of the change in sleep habits over longer time frames.

Future research on the ASBQ should address the reliability of the tool over different time frames, or different phases of the season with athletes (e.g. pre-season vs. in-season), and the relationship between the ASBQ and chronotype. Indeed, it is possible that morning and evening-type individuals may differ on some items of the ASBQ. It would also be useful to perform sleep monitoring via wrist-actigraphy for longer periods of time (e.g. 4 weeks) prior to filling out the ASBQ. This would allow for a direct comparison of the monitoring period with the surveyed time frame. It is proposed that the aforementioned studies are incorporated into phase two of the development of the ASBQ, as well as translating and validating the questionnaire in different languages.

The authors acknowledge that the Cronbach's α of 0.63 for the ASBQ is below the usually accepted threshold of 0.70, however, given this is a measure of internal consistency for the relationship between items in a questionnaire, this was not the aim of the practical tool being developed in the current study. Indeed, the ASBQ was intentionally designed to measure different aspects of sleep behavior, and therefore, it was not critical that all items on the questionnaire are related. The authors also acknowledge that the female athlete population was greater than the male athlete population surveyed, however, given there were no significant differences between male and female ASBQ scores, we did not see this as an issue impacting the validity or reliability of this questionnaire.

The authors would suggest that a ASBQ global score of ≤36 would equate to "good sleep behavior" and ≥42 = "poor sleep behavior". These thresholds are based on the authors' interpretation of the data and represent a conservative assessment of threshold range descriptors. The lower threshold of ≤36 would represent an average response of "rarely" for all 18-items, while the upper threshold of ≥42 would require more than one response of either "sometimes", "frequently" or "always". However, these thresholds are suggested as a guide only and are subject to adjustment in future studies assessing the sensitivity and specificity of the ASBQ in athletic populations.

The ASBQ that has been proposed and developed in phase one of the current study is an 18-item questionnaire that is a fast (<2 mins), easy to administer, valid and reliable tool that can help to identify the maladaptive sleep practices and challenges faced by athletes. The ASBQ offers a practical instrument for practitioners, coaches and/or researchers wanting to evaluate the sleep behaviors of elite athletes. The ASBQ is not designed to be a clinical sleep tool, but simply a practical solution to find out some of the key challenges faced by athletes in terms of their sleep behaviors. The ASBQ may also be a valuable tool for tracking changes in sleep habits over time, or for testing the efficacy of sleep-hygiene interventions to improve sleep. It may also be a useful tool for identifying the differences in sleep behaviors amongst sports with vastly different training loads and recovery needs.

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