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Monitoring athletes sleep: a survey of current trends amongst practitioners

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ABSTRACT

Achieving adequate sleep is considered important for athletic performance and recovery from exercise, yet the sleep monitoring methods applied amongst practitioners within high-performance sport are not well documented. This study aimed to identify the athlete sleep monitoring practices currently being implemented by practitioners working with full-time, junior (competing at the highest level), and semi-professional athletes. An online survey was developed and disseminated via email and social media to practitioners working with high-performance athletes. A sample of 145 practitioners completed the survey. Most (88%) practitioners rated sleep as 'extremely important' for recovery and performance (79%) and 84% of practitioners had advised athletes on improving sleep. The practitioners who reported monitoring sleep used several methods, including a questionnaire (37%), diary (26%) and actigraphy (19%). The most cited barrier to monitoring sleep was lack of time/resources. Most (79%) practitioners had not determined athletes' chronotypes. Over half (54%) of the practitioners suggested their athletes did not get enough sleep outside of competition periods; the highest ranked suggested reason for this was screen time (i.e., using electronic devices). Practitioners recognise the importance of sleep for athletes and sleep education/monitoring was common amongst the practitioners; however, chronotype analysis was not widely used. Most practitioners used questionnaires and diaries to monitor athletes' sleep and suggested that their athletes often experience insufficient sleep outside of competition periods.

1. Introduction

Elite athletes have previously identified sleep as being one of the most beneficial recovery strategies (Crowther et al., 2017; Venter, 2014); however, they often experience insufficient sleep during training or competition periods due to factors such as varied training/competition schedules and international travel (Gupta et al., 2017). Insufficient sleep can impair performance, and affect physiological markers of recovery (Skein et al., 2011). Therefore, sleep behaviour of athletes has been recognised as an important area to optimise (Driller et al., 2018; Fullagar et al., 2015; Halson, 2019) and has become a popular area of investigation (Claudino et al., 2019; Venter, 2014).

The gold standard for measuring sleep is laboratory polysomnography (PSG), which involves recording multiple neural and physiological variables (e.g., brain activity, eye movement, muscle tone). However, PSG is expensive and impractical, particularly when working with multiple athletes. Wristwatch actigraphy is a non-intrusive method of measuring sleep in the field, which has been validated against PSG for total sleep time and sleep efficiency measures (Sadeh, 2011). Consequently, actigraphy has been recommended for monitoring athletes' sleep (Sargent et al., 2016). A recent observational study, however, indicated the most popular sleep monitoring method used amongst practitioners within elite team sport was self-reported sleep diaries, with relatively little use of objective assessments or validated questionnaires (Miles et al., 2019). However, despite growing research into the area of sleep for athletes (Halson, 2019) and recommendations to monitor athletes sleep (Kellmann et al., 2018), there is limited empirical information available concerning how (and if) sleep monitoring practices are being applied within elite sport (Miles et al., 2019).

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Understanding practitioners' attitudes towards sleep and sleep monitoring practices will indicate if there are barriers to applying sleep monitoring and optimisation (e.g., sleep hygiene) interventions.

Humans typically have an interindividual preference for the timing of waking behaviours (e.g., social activities and exercise habits) and sleep, referred to as 'chronotype' (Adan et al., 2012). Those who prefer to wake and perform activities in the early morning are classified as 'early chronotypes' (ECTs); individuals who prefer to function later in the day are classified as 'late chronotypes' (LCTs), and those in between are 'intermediate chronotypes' (ICTs) (Adan et al., 2012). It has been suggested that chronotype influences sports performance, particularly amongst elite athletes (Vitale & Weydahl, 2017). Furthermore, there is potentially an interaction between chronotype and time of day that affects task performance meaning peak athletic performance occurs at different times of day between chronotypes (Facer-Childs & Brandstaetter, 2015). For example, ECTs have been shown to perform better at simple tasks (e.g., psychomotor vigilance, and grip strength) in the morning than LCTs (Facer-Childs et al., 2018). Therefore, it has been suggested that identifying athletes' chronotype could allow practitioners to optimise an athlete's performance (Facer-Childs et al., 2018), recovery (Sugawara et al., 2001) and sleep (Samuels, 2012). However, despite emerging research that highlights how chronotype and time of day could influence task performance, it is not clear if chronotype analysis is commonly adopted by practitioners.

There is currently limited information regarding how (or if) high-performance practitioners monitor athletes' sleep and identify chronotypes. The aim of this study was firstly to explore the methods of sleep monitoring and chronotype analysis adopted by practitioners working with high-performance athletes; and secondly to investigate the practitioners' attitudes regarding the importance of sleep for recovery and performance.

2. Methods

2.1. Survey development and design

An electronic database search using PubMed (MEDLINE) and Web of Science was undertaken to generate a list of sleep monitoring methods used with athletes. A thorough internal process of survey development and design was then conducted, which involved developing an online survey consisting of a combination of multiple-choice, scale/rank and Likert Scale questions using a survey provider (Jisc Online Surveys, Bristol, UK). Practitioners were asked to select answers from predetermined lists. Where applicable, a free text 'other' option was provided. The practitioners were required to provide three responses, in rank order, to one question (factors that contribute to athletes' insufficient sleep). Two questions focussed on the practitioners' attitudes towards sleep (rating the importance of sleep for recovery and performance); therefore, a balance of both positive and negative items was provided within a five-point Likert Scale to minimise response-set bias (Oskamp & Schultz, 2005).

A pilot version of the survey was disseminated to three academics and five high-performance practitioners. Following feedback, selected questions were modified to improve clarity. The survey was circulated again for feedback before the final version was disseminated. Ethical approval for the study was granted by the University Ethics Committee and the practitioners completed an electronic consent form before commencing the survey.

2.2. Procedure

A range of practitioners, such as sport scientists and strength and conditioning (S&C) coaches, working with professional soccer, rugby union, rugby league and cricket teams, and individual athletes within the United Kingdom were contacted via email to participate in the study. The email addresses of the practitioners were sourced via the personal contacts of the authors and internet searches. A link to the survey was also circulated internationally via social media between October 2019 and January 2020.

Practitioners were eligible to complete the survey if they were aged ≥ 18 years and working with high-performance athletes at the time of the survey. High-performance athletes were defined as: (1) full-time athlete (sport is the athlete's full-time occupation), (2) junior - age 12-18 years, competing at the highest level (e.g., academy, centre of excellence), and (3) semi-professional athlete (sport is the athlete's part-time occupation, for which they are remunerated).

2.3. Participants

One hundred and forty-five practitioners working within 30 different sports completed the survey (see Table 1). Data from five practitioners was removed from analyses due to the respondents working with amateur athletes and/or missing answers. As shown in Table 1, most of the practitioners were Strength and Conditioning Coaches (n = 62) and Sport Scientists (n = 29).

2.4. Statistical approach

Frequency analysis for each question was conducted, with results presented as absolute frequency counts and percentages. Sub-group analyses to examine the relationships between selected categorical variables were conducted using cross-tabulation and Chi-Square analyses. For the question 'Why do you think your athletes do not get enough sleep outside of competition periods?' the practitioners selected three responses in rank order. Analysis of ranks was performed by assigning ranking points (primary reason = 3 points, 2nd reason = 2 points, 3rd reason = 1 point) to the three selected reasons. The total ranking scores for each reason were then summed to tabulate an overall ranking.

Table 1: Practitioner demographics

Age	Count	%
18-30	49	35%
31-40	54	39%
41-50	30	21%
51-60	5	4%
>60	2	1%
Role		
Sport Scientist	29	21%
S&C Coach	62	44%
Performance Analyst	2	1%
Sport Rehabilitator	2	1%
Exercise Physiologist	7	5%
Nutritionist	8	6%
Physiotherapist	11	8%
Doctor / Medic / Physician	3	2%
Technical Coach	6	4%
Other	10	7%
Level of athletes supported		
Senior (full-time occupation)	93	66%
Senior (semi-professional) *	25	18%
Junior (12-18 years) **	22	16%
Sex of athletes supported		
Predominantly male	78	57%
Predominantly female	18	13%
Mixed group	42	30%
Sports		
Athletics (track & field)	5	4%
Basketball	2	1%
Boxing	1	1%
Cricket	7	5%
Cycling	4	3%
Football (soccer)	33	24%
Ice hockey	4	3%
Golf	1	1%
Rugby league	2	1%
Rugby Union	23	16%
Martial arts	1	1%
Motor sport	11	8%
Running	5	4%
Rowing	2	1%
Sailing	3	2%
Strength (powerlifting, body building, weightlifting)	3	2%
Swimming	8	6%
Tennis	5	4%
Triathlon	2	1%
Winter sports	4	3%
Other	14	10%

Note: *Part-time occupation; ** Competing at the highest level (e.g., academy, centre of excellence)

3. Results

3.1. Athlete sleep education

Most (89%) practitioners reported offering advice to athletes on improving sleep. This information was provided via in-house education (74%), an external consultant (16%), app-based training (6%), and a combination of approaches (4%) – see Figure 1A. Chi-Square analysis indicated a significant association between the level of athlete supported and the type of sleep education provided (Likelihood ratio = 14.1, $p > 0.05$). Analysis of adjusted residuals indicated that practitioners working with full-time senior athletes used external consultants (n = 17) more than practitioners working with semi-professional (n = 0) and junior athletes (n = 3).

3.2. Athlete sleep monitoring

Overall, 61% of respondents had monitored athletes' sleep within the previous year. Sub-group analysis revealed that 63%, 64% and 50% of practitioners working with full-time, junior, and part-time athletes monitored sleep, respectively. The sleep monitoring methods adopted amongst all practitioners were: sleep questionnaire (37%), sleep diary/journal (26%), wrist actigraphy (19%), mobile phone app (15%), finger actigraphy [Oura ring®] (2%) and other methods (1%) – see Figure 1C.

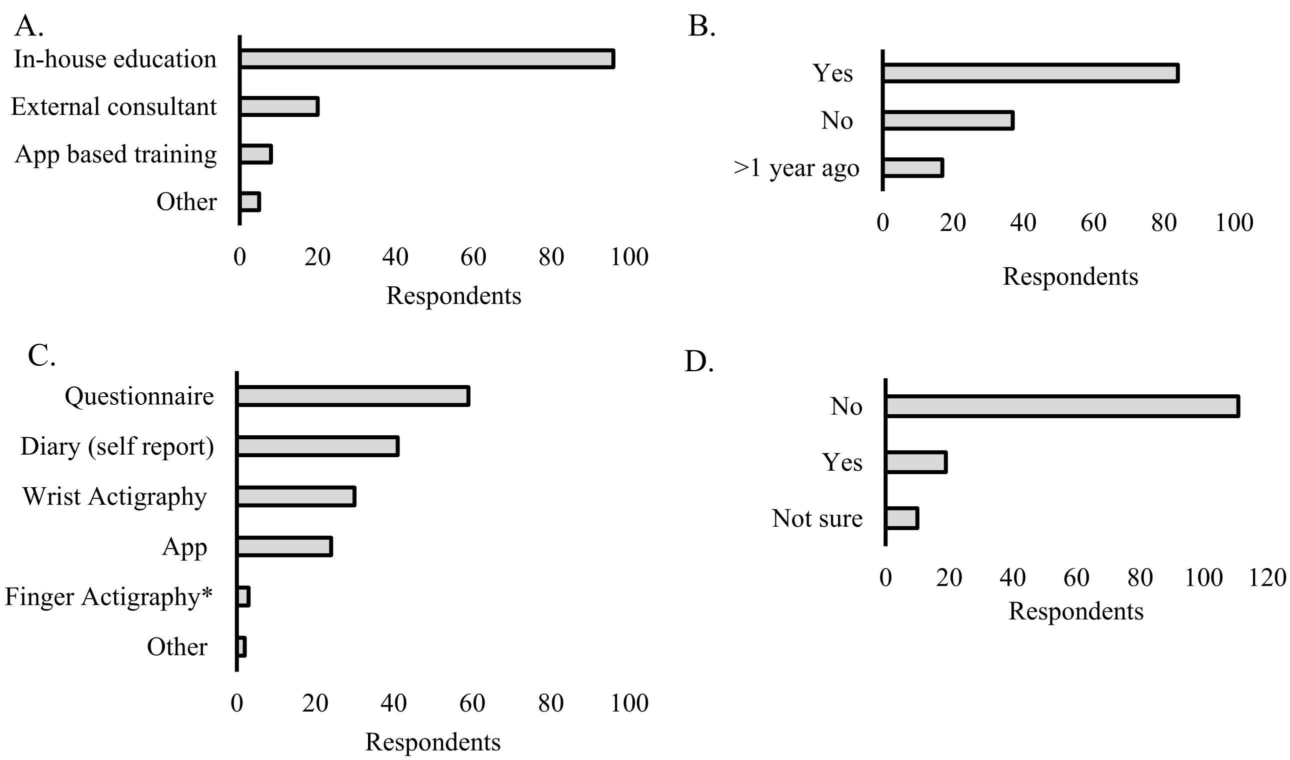
The commonly cited barriers from the practitioners (n = 44) who reported they did not monitor athletes' sleep, were a lack of time/resources (39%), poor athlete compliance (14%), and being unsure of how to measure sleep effectively (14%).

3.3. Chronotype analysis

Most (79%) practitioners had not attempted to determine their athletes' chronotypes (see Figure 1D). The practitioners (n = 19) that had assessed chronotype used the following methods: asked the athlete (n = 5), bespoke questionnaire (n = 5), Morning-eveningness questionnaire (n = 3), sleep/wake data (n = 2), Munich Chronotype questionnaire (n = 2), a combination of approaches (n = 2).

3.4. Importance of sleep

When asked to rate how important sleep was for athletes' recovery after training/competition (1-5 Likert Scale), 88% of participants specified it was 'extremely important', 11% 'very important' and 1% 'moderately important'. When rating the importance of sleep



Note: A: Sleep education method; B: Have you monitored athletes sleep?; C: Sleep monitoring method; D: Have you monitored athletes chronotype? * = Oura ring®

Figure 1: Responses to sleep and chronotype monitoring questions

for performance, 79% of practitioners specified it was ‘extremely important’, 18.1% ‘very important’, 2.2% ‘moderately important’ and 0.7% ‘slightly important’. Chi-square analysis revealed the level of athlete supported did not have a significant effect on the ratings of sleep for recovery ($X^2 = 0.92$, $p > 0.05$) or performance ($X^2 = 0.92$, $p > 0.05$).

3.5. Do athletes get enough sleep (practitioners’ perceptions)

Most (54%) respondents believed their athletes did not get enough sleep outside of competition periods; 28% of practitioners believed their athletes obtained enough sleep and 18% were unsure. The practitioners based their answer on observations/anecdotes (51%), analysis of subjective (31%) and objective (14%) sleep data and other methods (4%). The sub-group analysis revealed a higher proportion of no (not enough sleep) responses with junior (56%) and semi-professional athletes (64%) than full-time athletes (48%). However, there was no significant association between the level of athlete and reports of insufficient sleep ($X^2 = 3.97$, $p > 0.05$). Screen time (TV, mobile devices etc.) was the highest-ranked reason (268 points) by all practitioners for insufficient sleep. Sub-group analysis revealed that screen time was cited as the main reason by 35% of the practitioners working with full-time athletes, 48% working with junior athletes and 36% with semi-professional athletes. The ranked responses for insufficient sleep are presented in Figure 2.

3.6. Sleep supplements

Most (69%) practitioners had not recommended a sleep supplement for their athletes. A higher proportion (39.6%) of practitioners working with full-time athletes recommended sleep supplements compared to practitioners working with junior (8%) and semi-professional (22.7%) athletes. The supplements recommended by practitioners working with full-time athletes were: melatonin (n = 28), tart cherry juice (n = 19), magnesium (n = 17), ZMA (n = 11), chamomile tea, (n = 9), L-tryptophan (n = 3), 5-HTP (n = 2), valerian (n = 1), and herbal sleep tablet (n = 1).

4. Discussion

The present study explored practitioners’ views on sleep and the application of sleep monitoring methods amongst athletes. The majority of practitioners specified that sleep was ‘extremely important’ for athletes’ recovery (89%) and performance (79%). The most common sleep monitoring method was questionnaires, adopted by 37% of the practitioners. The commonly cited barriers from practitioners who did not monitor athletes’ sleep, were a lack of time/resources, poor athlete compliance and being unsure of how to measure sleep effectively. The practitioners suggested that athletes do not consistently achieve adequate sleep, and most practitioners had not explored the chronotype of their athletes.

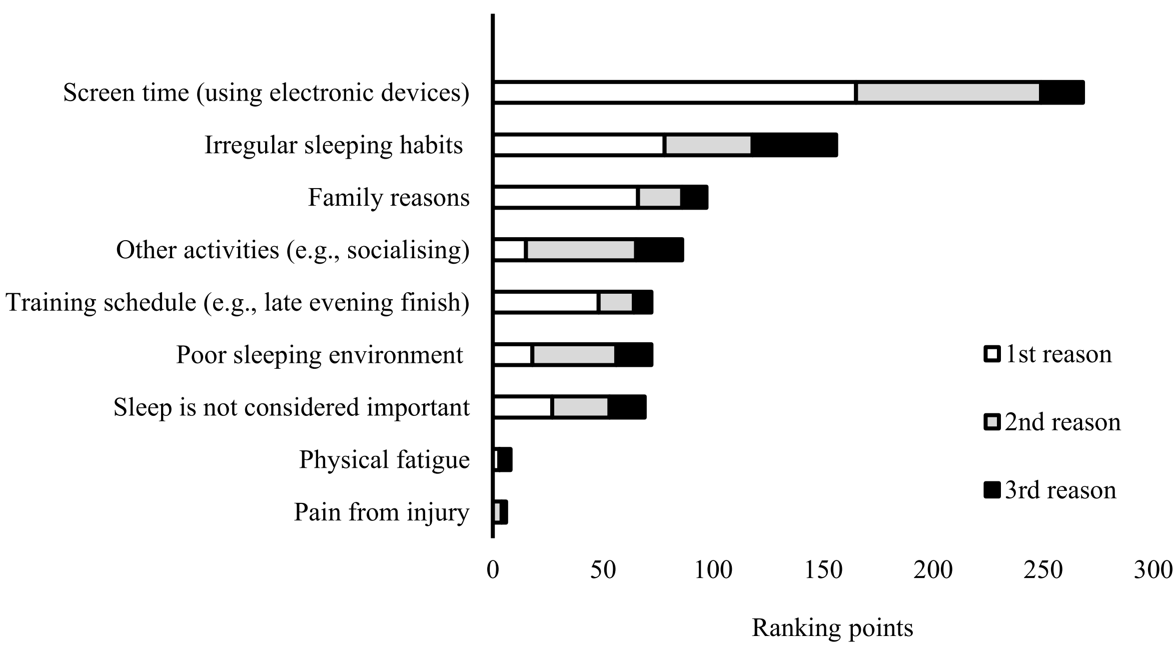


Figure 2: Practitioners perceived reasons for athletes’ lack of sleep outside of competition periods.

The majority (89%) of respondents provided sleep advice to athletes and (60%) reported monitoring athletes' sleep. These findings parallel a recent study where 56% of practitioners working within Australian high-performance sports teams reported monitoring athletes' sleep (Miles et al., 2019). In the same study, those who did not implement sleep monitoring or sleep hygiene practices with athletes specified this was due to lack of resources (60%) and lack of time (23%) (Miles et al., 2019). Similarly, the main factor for not implementing sleep monitoring practices in the present study was a lack of time/resources (39%). The lack of time/resources could explain why a sleep questionnaire (37%) and self-report diaries (26%) were the most popular methods of monitoring sleep both here and in the previous research (Miles et al., 2019).

Sleep questionnaires are commonly used in healthcare to provide a subjective measure of patients' sleep quality and were the most popular sleep monitoring method in the present study. Although several questionnaires have been validated amongst the general population, their validity for evaluating sleep amongst athletes has been questioned (Driller et al., 2018; Samuels et al., 2016). Therefore, athlete-specific sleep questionnaires, such as the Athlete Sleep Screening Questionnaire (Samuels et al., 2016) and The Athlete Sleep Behaviour Questionnaire (Driller et al., 2018), have been developed and validated. Athlete-specific questionnaires offer a practical sleep method to identify athletes with sub-optimal sleeping patterns and behaviours. However, sleep questionnaires may not be appropriate for monitoring sleep longitudinally, as adherence to completing sleep questionnaires can decrease over time compared to wearing a wristwatch actigraphy device (Thurman et al., 2018).

A sleep diary was the second most prevalent monitoring method adopted in the present study. As with questionnaires, sleep diaries are practical and cost effective. However, practitioners should be aware of the potential limitations of self-reported sleep diaries, such as athletes overestimating their sleep duration (Caia et al., 2018) and misreporting sleep onset and wake times due to a failure of memory or a reduced effort in completing sleep records (Thurman et al., 2018). Practitioners may consider using electronic, app-based sleep diaries as an alternative to paper diaries as these can be downloaded to personal devices (phones and tablets) and offer several benefits, such as being more time efficient, reducing data hording (completing several days data retrospectively), and providing automatic calculations (Tonetti et al., 2016). Regardless of the method, practitioners should apply caution when using subjective sleep data gathered from questionnaires and diaries to inform decision making as the long-term reliability of questionnaires (Driller et al., 2018; Samuels et al., 2015) and diaries has not been established amongst athletes.

Due to the limitations of subjective sleep monitoring methods, it is recommended that questionnaires and diaries are used in conjunction with actigraphy (Halson, 2019). Although the collection of sleep data is simple using actigraphy, data analysis from research-grade activity monitors (e.g., Philips Respironics ActiWatch 2) can be time-consuming, which could explain why actigraphy was not the most widely implemented method in the present study. Commercially available activity monitors automatically generate sleep reports and offer a convenient and economical means to objectively measure sleep. However, several devices use proprietary algorithms and direct sensor outputs that have not been independently validated, which raises questions over their accuracy (de Zambotti et al., 2020). Actigraphy devices that automatically analyse sleep data have been developed and validated amongst athlete populations (Driller et al., 2016) . These tools provide practitioners with a more time-efficient, but not necessarily economical, method to objectively monitor athletes' sleep.

In summary, validated questionnaires and sleep diaries offer an economical method of monitoring athletes sleep. To improve accuracy, and possibly long-term adherence, actigraphy used in conjunction with a validated questionnaire or sleep diary is currently the recommended sleep measurement method for athletes. In all cases, practitioners should understand the limitations of each method to ensure the data is suitably interpreted and communicated to athletes.

Researchers have suggested that the time of day when peak athletic performance occurs could be moderated by chronotype (Facer-Childs & Brandstaetter, 2015; Facer-Childs et al., 2018), and identifying inter-individual differences in circadian rhythmicity could prove valuable when planning training schedules (Vitale & Weydahl, 2017). However, 79% of practitioners in the present study had not attempted to determine their athletes' chronotype. Given that chronotype can be assessed using simple validated questionnaires, such as the Morningness-Eveningness Questionnaire (MEQ) and the Munich Chronotype Questionnaire (MCTQ), chronotype assessment could present an opportunity for practitioners to individualise schedules to minimise circadian disruption, enhance performance (Facer-Childs & Brandstaetter, 2015; Lastella et al., 2015), improve the reliability of performance/recovery assessments (Brown et al., 2008), and optimise sleep (Samuels, 2012).

Sleep has been recognised as the most beneficial recovery strategy amongst international athletes (Crowther et al., 2017). However, athletes often experience insufficient sleep within competition periods due to factors such as training/competition schedules and frequent travel (Gupta et al., 2017). Less is known regarding what factors affect athletes' sleep outside competition periods. In the present study, 'screen time' was the highest ranked reason for athletes' not achieving sufficient sleep outside of competition periods. This suggestion is consistent with observational studies that have reported the use of electronic devices before bedtime is common amongst elite youth athletes (Knufinke et al., 2018) and professional basketball players (Jones et al., 2019). Delaying bedtime, termed 'bedtime procrastination', could be due to electronic devices providing more extrinsic appeal than going to bed, i.e., individuals want to sleep, but do not want to stop using their devices (Kroese et al., 2014). Furthermore, exposure to electronic devices before bedtime can increase excitatory stimuli and suppress melatonin secretion and, consequently, reduce sleep duration/quality (de la Iglesia et al., 2015).

Regardless of the mechanism underpinning bedtime procrastination, sleep curtailment can harm recovery and performance (Fullagar et al., 2015). Consequently, future research on strategies to reduce bedtime procrastination amongst athletes is warranted. For example, Kroese et al. (2014) suggested that strategies that do not require cognitive resources, such as implementation intentions (i.e., an "if – then" plan), could be effective in reducing bedtime procrastination. Additionally, since blue light exposure from electronic devices could be detrimental to sleep, strategies to reduce blue light exposure in the evening (e.g., blue light blocking glasses) present a further area for investigation.

Most (69%) practitioners had not recommended sleep supplements, which could be attributed to the few (n = 8) nutritionists/dieticians amongst the sample. It is also possible that practitioners recognised that the factors they suggested had a negative impact on athletes' sleep would not be improved by supplements (e.g., screen time and irregular sleeping habits). The limited evidence for the efficacy of sleep supplements and requirement for strict batch testing for contaminants could also explain why supplements were not widely recommended. Moreover, behavioural and dietary interventions may offer a more practical and sustainable approach to optimising sleep (Halson, 2014).

4.1. Limitations

This study provides an insight into practitioners' views on sleep and the methods currently being used to monitor athletes' sleep. The practitioners were recruited from the authors professional network and via social media; therefore, the results are not generalisable to those working with unrepresented sports or amateur athletes. The results of this cross-sectional survey are based on the opinions of practitioners working with full-time, junior and semi-professional athletes. Although a sub-analysis was conducted, most of the practitioners worked with full-time athletes and the overall responses may not be representative of practitioners working with junior and semi-professional athletes. Furthermore, although the practitioners specified the general sleep monitoring methods used, the exact instrument(s) adopted was not specified. Future surveys may seek to target one particular category of practitioner (e.g., those working with junior athletes) and ask respondents to specify the sleep monitoring instrument(s) applied (e.g., specify the sleep questionnaire). Finally, responses based on the subjective opinions of the practitioners (e.g., athletes do not consistently achieve adequate sleep outside of competition periods) should be interpreted with caution.

4.2. Conclusions

Questionnaires and diaries were the most frequently used methods amongst those who monitored sleep; however, the long-term reliability of these subjective methods requires investigation amongst athletes. To improve accuracy, and potentially adherence, practitioners should consider using validated activity monitors and/or app-based sleep diaries. Very few practitioners attempted to determine their athletes chronotypes. Although chronotype and sports performance research is limited, understanding an athlete's chronotype could potentially facilitate the design of training, testing and sleep schedules. The practitioners believed their athletes experienced insufficient sleep outside of competition periods. The highest ranked reason for insufficient sleep was screen time. Previous research suggests the use of electronic devices can lead to bedtime procrastination and sleep curtailment; therefore, future research on strategies to reduce bedtime procrastination amongst athletes is warranted.

Conflict of Interest

The authors declare no conflict of interests.

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