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SCIENTIFIC INVESTIGATIONS

Assessment of sleep health in collegiate athletes using the Athlete Sleep Screening Questionnaire

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Study Objectives: The objective of this study was to characterize sleep health in a large, diverse population of college athletes. The study utilized the Athletic Sleep Screening Questionnaire, a clinically validated questionnaire, designed to screen athletes for a clinically significant degree of poor sleep health, and to determine if they require intervention.

Methods: College athletes from 4 different National College Athletic Association institutions were surveyed using the Athletic Sleep Screening Questionnaire. Descriptive information including sex, sport, and college year was also collected. The Athletic Sleep Screening Questionnaire was scored according to prior clinically validated methods to determine a sleep difficulty score, clinical sleep problem category (none, mild, moderate, or severe), and need for assessment by a physician due to poor sleep health.

Results: A total of 1055 surveys were collected with a 95% response rate. Respondents were 36% female, 64% male, and included athletes competing in 15 different sports. Approximately 25% of participants were found to have a clinically meaningful problem with their sleep. Athletes entering their second or higher year of college were more likely to report worse sleep compared to those entering their first year (one-way analysis of variance, Kruskall-Wallis $P < .001$).

Conclusions: A substantial portion of college athletes experience poor sleep health and would benefit from interventions aimed at improving sleep. The Athletic Sleep Screening Questionnaire appears to be a cost- and time-efficient way to evaluate sleep health in a large athletic population.

Keywords: athlete, college, sport, sleep

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BRIEF SUMMARY

Current Knowledge/Study Rationale: College athletes face unique lifestyle stressors that may affect the quantity and quality of their sleep. However, the incidence and severity of poor sleep health among such athletes is not well understood.

Study Impact: The present study evaluates the sleep health of a large, diverse sample of college athletes. The findings suggest that a substantial portion of college athletes experience poor sleep health and would benefit from interventions aimed at improving sleep.

INTRODUCTION

Adequate sleep is critical for optimal cognitive and physical performance. This is especially relevant to competitive athletes, who are required to consistently perform in and to recover quickly from both cognitively and physically demanding activities. Athletes may furthermore be at high risk of poor quality sleep due to unique lifestyle stressors, and several recent studies have found that athletes frequently suffer from inadequate sleep and related impairments, often at higher rates than the general population.[1–11] However, many of these investigations were conducted in small and/or highly homogeneous populations and employed highly variable methodologies. Hence there is a need to prospectively investigate the sleep health of athletes, to conduct the studies in large, diverse populations, and to use validated methods.

In general, there is lack of consensus on how to best evaluate sleep quality, patterns, and behaviors in athletes. This is not only of interest to researchers but also to sports medicine clinicians who coordinate care for large numbers of athletes and need valid, reliable, and economical ways to assess sleep health. Clinical methods such as polysomnography, actigraphy, and interviews with sleep specialists can provide high-quality diagnostic information but are time- and resource-intensive.[5,12] Questionnaires in contrast provide a more efficient and economical way to evaluate sleep quality, patterns, and behaviors in large populations.[12] Several different sleep questionnaires applied to large athletic populations have been reported on, such as the Pittsburgh Sleep Quality Index (PSQI), Sleep Hygiene Index, and Epworth Sleepiness Scale.[2,4] Although the PSQI is most commonly used to evaluate sleep in athletes, it is difficult to score, lacks information specific to athletes, has not been validated in athletic populations, and has demonstrated poor concordance with clinical assessment conducted by a sleep medicine physician.[1,5,13] Sleep Hygiene Index and Epworth Sleepiness Scale similarly have not been validated in athletic populations and lack questions specific to the challenges faced by athletes.[2] More recently the Athletic Sleep Behavior Questionnaire (ASBQ) was developed to evaluate maladaptive sleep behaviors

in athletes.[2] Although the ASBQ is a promising athlete-specific instrument, it has a somewhat limited utility as a diagnostic tool as it is intended to inform sleep hygiene recommendations, not to assess athletes for clinically relevant sleep problems.[1]

The Athletic Sleep Screening Questionnaire (ASSQ) in contrast is a recently developed, clinically validated tool, designed to screen athletes for clinically relevant issues related to their sleep.[1,5] The intended use of the ASSQ is to determine if an athlete is in need of further assessment and an intervention specific to sleep-related issues. The development and design of the ASSQ was reported by Samuels et al. and Bender et al.[1,5] Briefly, the ASSQ is a 16-item multiple-choice questionnaire that can be completed and scored in less than 15 minutes. Five questions are used to calculate a "Sleep Difficulty Score" (SDS) based on total sleep time, satisfaction with sleep, and presence of insomnia symptoms. The SDS, along with scoring of several other questions that evaluate chronotype and sleep-disordered breathing, are then translated into specific interventional recommendations. The ASSQ has been demonstrated to be valid and reliable in athletic populations as described by Bender et al.[1]

Among sleep questionnaires, the ASSQ arguably provides the most accurate assessment of an athlete's sleep heath and need for sleep health intervention. However, results of the validated ASSQ have not been reported in a large, diverse athletic population. Considering this, and the need for a better understanding of sleep as it relates to the athlete, the purpose of this study was to characterize the sleep quality and interventional needs of a large, diverse population of collegiate athletes via survey with the ASSQ. Based on prior reports, it was hypothesized that a substantial portion of college athletes would be shown to have clinically relevant sleep problems. Such findings have important implications for all athletes, coaches, and professionals interested in optimizing sleep to improve sports performance, but particularly for sports medicine clinicians who oversee large, multisport athletic programs and can use the ASSQ as an efficient and economical tool to improve the health and performance of their athletes.

METHODS

Data collection

Institutional board approval was obtained for this study (Cleveland Clinic, protocol number 18-794). Athletes enrolled in 4 different National College Athletic Association (NCAA) institutions were surveyed with the ASSQ. One institution was NCAA division I, one was NCAA division II, and two were NCAA division III. Surveys were administered during annual physicals and practices prior to the start of the school calendar year. The questionnaire was anonymous, and produced de-identified data. Informed consent was obtained from each participant prior to beginning the questionnaire. The survey included the 16 item ASSQ as described by Bender et al.[1] In addition to the ASSQ, descriptive information was collected in the same survey, including sex, sport, height, weight, and year of college entry.

ASSQ scoring

The ASSQ was scored as described by Bender et al.[1] Eleven questions from the ASSQ are used to determine whether or not an athlete needs further assessment by a physician. Five of these questions are used to calculate SDS on an 18-point scale. SDS is then used to stratify participants into 4 categories describing the condition of their sleep: none (SDS of 0–4), mild (SDS of 5–7), moderate (SDS of 8–10), and severe (SDS of 11–17). Four questions are then used to calculate chronotype on a 15-point scale. Respondents are next classified as having an evening chronotype if their score was less than 5. Respondents are classified as having sleep-disordered breathing if they answered "Yes" to at least 1 of 2 questions on the ASSQ investigating frequency of snoring, choking, or gasping during sleep. Athletes are then identified for further assessment if they have an SDS category of moderate or severe, an evening chronotype, or sleep-disordered breathing. Five additional questions on the ASSQ, not included in scoring, evaluate napping habits, caffeine intake, electronic device use before bed, and travel-related sleep disturbance.

Statistical analysis

Categorical variables were summarized with frequency and percent. Height, weight, body mass index, and SDS were summarized with means and standard deviation. Independent sample *t* tests were used to compare mean SDS scores between sex groups. One-way analysis of variance was used to compare mean SDS scores between college year and between different sports. Kruskal-Wallis tests were used to compare clinical sleep problem categories between sex and college year. Post hoc pairwise comparison using Bonferroni adjustment was used to determine which college years were significantly different from each other in both mean SDS and clinical sleep problem category. Linear regression analysis was used to determine factors associated with differences in SDS. A *P*-value of .05 was set as the threshold for statistical significance. Statistical tests were performed with Stata (Version 15.1., StataCorp LLC, College Station, TX).

RESULTS

Sample characteristics

A total of 1,115 questionnaires were administered and 1,055 completed questionnaires were collected, a 94.6% response rate. Of all athletes, 673 (63.8%) were male and 382 (36.2%) were female (**Table 1**). By college year, 593 athletes (56.2%) were entering their first year of college, 190 (18.0%) had attended college for 1 year, 169 (16.0%) had attended college for 2 years, 87 (8.2%) had attended college for 3 years, and 16 (1.5%) had attended college for 4 years, and were entering their fifth year of college (**Table 1**). Fifteen different sports were represented among the athletes, with 48 (4.5%) reporting participation in more than one sport (**Table 2**).

Sleep difficulty score

SDS is measured on a scale of 0–17 with a higher value indicating a greater sleep problem. Mean SDS was 5.8 (±2.7), with men scoring 5.7 (±2.6) and women scoring 6.0 (±2.9), $P = .24$, indicating females had greater sleep difficulty compared to males. There was a statistically significant difference in mean SDS between men and women ($P = .024$) (**Table 3**). Mean SDS was 5.4 (±2.4) for athletes entering their first year of college, 6.2 (±2.9) for athletes who had attended college for 1 year, 6.4

Table 1—Participant characteristics across sex categories.

	Total		Men		Women	
	No.	%	No.	%	No.	%
Number	1055	—	673	63.8%	382	36.2%
College year[a]						
0	593	56.2%	411	61.1%	182	47.6%
1	190	18.0%	95	14.1%	95	24.9%
2	169	16.0%	104	15.5%	65	17.0%
3	87	8.2%	53	7.9%	34	8.9%
4	16	1.5%	10	1.5%	6	1.6%
School (NCAA division)						
1 (I)	195	18.5%	93	13.8%	102	26.7%
2 (II)	413	39.1%	265	39.4%	148	38.7%
3 (III)	286	27.1%	197	29.3%	89	23.3%
4 (III)	161	15.3%	118	17.5%	43	11.3%
Height in cm (SD)	176.0 (±10.2)		180.6 (±8.4)		167.9 (±7.5)	
Weight in kg (SD)	78.7 (±18.0)		85.5 (±17.2)		66.8 (±12.4)	
Body mass index (kg/m^2) (SD)	25.2 (±4.5)		26.1 (±4.5)		23.7 (±3.8)	

Categorical variables are reported with frequencies and percent. Height, weight, and body mass index are reported as mean (standard deviation [SD]).
[a]College year describes the number of cumulative years the athlete has attended college.

Table 2—Represented sports.

Sport	Total (n = 1055)		Men (n = 673)		Women (n = 382)	
	No.	%	No.	%	No.	%
Baseball	78	7.4%	78	11.6%	—	—
Basketball	98	9.3%	56	8.3%	42	11.0%
Bowling	29	2.7%	16	2.4%	13	3.4%
Cross country	39	3.7%	14	2.1%	25	6.5%
Football	233	22.1%	233	34.6%	—	—
Golf	22	2.1%	8	1.2%	14	3.7%
Lacrosse	102	9.7%	71	10.5%	31	8.1%
Rugby	18	1.7%	8	1.2%	10	2.6%
Soccer	138	13.1%	83	12.3%	55	14.4%
Softball	78	7.4%	—	—	78	20.4%
Swimming and diving	65	6.2%	45	6.7%	20	5.2%
Tennis	14	1.3%	4	0.6%	10	2.6%
Track and field	93	8.8%	30	4.5%	63	16.5%
Volleyball	47	4.5%	0	—	47	12.3%
Wrestling	50	4.7%	50	7.4%	—	—

Number and percent of athletes participating in each sport are reported. Sport categories are not mutually exclusive, as 48 athletes (4.5%) reported participation in more than one sport. Of multisport athletes 22 were male (3.3% of all male athletes) and 26 were female (6.8% of all female athletes).

(±3.0) for athletes who had attended college for 2 years, 6.1 (±3.0) for athletes who had attended college for 3 years, and 7.2 (±2.9) for those who had attended college for 4 years (**Table 3**). There was a statistically significant difference between SDS of athletes entering different years of college ($P < .001$). Post hoc pairwise comparisons revealed statistically significant differences in mean SDS between athletes entering college (year 0) and athletes who had completed 1, 2, and 4 years of college ($P < .001$). No statistically significant difference was found in mean SDS between different sports.

Clinical sleep problem category

SDS is used to stratify athletes into 4 clinical sleep problem categories, which are: none(SDS 0–4), mild (SDS 5–7), moderate

Table 3—Mean SDS by sex, sport, and college year.

	Total		Men*		Women*	
	Mean	SD	Mean	SD	Mean	SD
All athletes	5.8	±2.7	5.7	±2.6	6.0	±2.9
College year***						
0[b,c,e]	5.4	±2.4	5.4	±2.4	5.4	±2.4
1[a]	6.2	±2.9	6.0	±2.8	6.4	±3.0
2[a]	6.4	±3.0	6.1	±2.8	6.7	±3.2
3	6.1	±2.8	5.6	±2.5	6.8	±3.1
4[a]	7.2	±2.9	7.3	±3.1	7.0	±2.8
Sport						
Baseball (men only)	5.1	±2.8	—	—	—	—
Basketball	5.9	±2.8	5.9	±2.8	5.8	±2.8
Bowling	6.0	±2.6	5.1	±2.4	7.0	±2.5
Cross country	5.8	±2.3	5.6	±1.6	5.9	±2.7
Football (men only)	5.9	±2.7	—	—	—	—
Golf	6.4	±3.1	5.3	±2.4	7.0	±3.3
Lacrosse	5.6	±2.2	5.4	±2.1	6.1	±2.6
Rugby	4.5	±2.4	4.2	±2.2	4.7	±2.6
Soccer	5.9	±2.8	5.7	±2.6	6.3	±3.0
Softball (women only)	6.7	±3.0	—	—	—	—
Swimming and diving	5.8	±2.7	5.8	±2.9	5.8	±2.3
Tennis	5.9	±3.1	6.0	±3.4	5.8	±3.2
Track and field	5.8	±2.5	5.4	±2.3	6.0	±2.6
Volleyball (women only)	4.9	±2.6	—	—	—	—
Wrestling (men only)	5.8	±2.7	—	—	—	—
Multisport	5.8	±2.6	5.3	±2.4	6.1	±2.7

Sleep Difficulty Score (SDS) is measured on a scale of 0–17 with a higher value indicating greater sleep difficulty. SDS is reported as mean and standard deviation, stratified by sex, sport, and entering year of college. Statistically significant differences were found between sex (independent sample *t* test $P = .024$), and college year (one-way ANOVA $P < .001$). For statistical significance *indicates $P \leq .05$ and ***indicates $P \leq .001$. For post hoc pairwise comparisons between college year ($P \leq .05$), [a]indicates statistically significant difference from year 0, [b]indicates statistically significant difference from year 1, [c]indicates statistically significant difference from year 2, [d]indicates statistically significant difference from year 3, and [e]indicates statistically significant difference from year 4. SD = standard deviation.

(SDS 8–10), and severe (SDS 11–17). Of all athletes, 34.4% were in the none sleep problem category, 41.9% were in the mild sleep problem category, 18.3% were in the moderate sleep problem category, and 5.4% were in the severe sleep problem category. Female athletes and those who had completed one or more years of college were more likely to be categorized as having moderate to severe clinical sleep problems (**Table 4**). Statistically significant differences were found between sex ($P = .044$) and college year ($P < .001$). Post hoc pairwise comparisons revealed statistically significant differences in clinical sleep problem category between athletes entering college (year 0) and athletes who had completed 1, 2, and 4 years of college ($P < .001$). No statistically significant differences were found between clinical sleep problem category and sport.

Intervention needs

Athletes were identified as requiring further assessment by a physician if they had a moderate or severe clinical sleep problem categories, an evening chronotype, or sleep-disordered breathing. In total, 42.0% of athletes were identified for further assessment, including 43.8% of male athletes and 38.5% of female athletes. **Table 5** shows the number and percentage of athletes requiring referral for further assessment by sex, sport, and college year. Of the 442 athletes requiring referral for further assessment, 56.6% were in the moderate or severe clinical sleep problem categories, 25.1% were of evening chronotype only, 15.2% showed sleep-disordered breathing only, and 3.2% were of evening chronotype and sleep-disordered breathing only. Of women requiring referral for assessment, 70.7% were in the moderate or severe clinical sleep problem categories vs 49.5% for men. Greater proportions of men required further assessment due to evening chronotype alone (27.5% for men vs. 20.4% for women) and sleep-disordered breathing alone (19.3% for men vs. 6.8% for women) (**Table 6**).

Factors associated With SDS

Linear regression analysis was used to determine factors associated with differences in SDS. Univariate analyses were

Table 4—SDS clinical sleep problem categories.

	None		Mild		Moderate		Severe	
	No.	%	No.	%	No.	%	No.	%
Total	363	34.4%	442	41.9%	193	18.3%	57	5.4%
Sex*								
Men	241	35.8%	286	42.5%	117	17.4%	29	4.3%
Women	122	31.9%	156	40.8%	76	19.9%	28	7.3%
College year***								
0[bce]	227	38.3%	258	43.5%	90	15.2%	18	3.0%
1[a]	61	32.1%	69	36.3%	45	23.7%	15	7.9%
2[a]	51	30.2%	63	37.3%	39	23.1%	16	9.5%
3	22	25.3%	45	51.7%	14	16.1%	6	6.9%
4[a]	2	12.5%	7	43.8%	5	31.3%	2	12.5%

Sleep Difficulty Score (SDS) is used to stratify athletes into four clinical sleep problem categories, which are: none (SDS 0–4), mild (SDS 5–7), moderate (SDS 8–10), and severe (SDS 11–17). Statistically significant differences were found between sex ($P = .044$) and college year ($P < .001$), determined by Kruskal-Wallis tests. For statistical significance, *indicates $P \leq .05$ and ***indicates $P \leq .001$. For post hoc pairwise comparisons between college year ($P \leq .05$), [a]indicates statistically significant difference from year 0, [b]indicates statistically significant difference from year 1, [c]indicates statistically significant difference from year 2, [d]indicates statistically significant difference from year 3, and [e]indicates statistically significant difference from year 4.

Table 5—Number and percent of athletes identified for physician's assessment.

	Total (n = 1055)		Men (n = 673)		Women (n = 382)	
	No.	%	No.	%	No.	%
All athletes	442	42.0%	295	43.8	147	38.5
Year						
0	234	39.5%	176	42.8%	58	31.9%
1	86	45.3%	44	46.3%	42	44.2%
2	78	46.2%	50	48.1%	28	43.1%
3	33	37.9%	18	34.0%	15	44.1%
4	11	68.8%	7	70.0%	4	66.7%
Sport						
Baseball (men only)	38	48.7%	—	—	—	—
Basketball	40	40.8%	25	44.6%	15	35.7%
Bowling	9	31.0%	2	12.5%	7	53.8%
Cross country	11	28.2%	2	14.3%	9	36.0%
Football (men only)	114	48.9%	—	—	—	—
Golf	14	63.6%	5	62.5%	9	64.3%
Lacrosse	39	38.2%	27	38.0%	12	38.7%
Rugby	5	27.8%	2	25.0%	3	30.0%
Soccer	63	46.3%	36	43.4%	27	50.9%
Softball (women only)	33	42.3%	—	—	—	—
Swimming and diving	20	30.8%	16	35.6%	4	20.0%
Tennis	4	28.6%	2	50.0%	2	20.0%
Track and field	35	37.6%	8	26.7%	27	42.9%
Volleyball (women only)	11	23.4%	—	—	—	—
Wrestling (men only)	22	44.0%	—	—	—	—
Multisport	16	33.3%	4	18.2%	14	53.8%

Athletes are indicated for further assessment due to moderate or severe clinical sleep problem categories, evening chronotype, or sleep-disordered breathing.

Table 6—Reason for needing assessment by a physician.

Reason for Assessment	Total (n = 442)		Men (n = 295)		Women (n = 147)	
	No.	%	No.	%	No.	%
Moderate or severe clinical sleep problem category	250	56.6%	146	49.5%	104	70.7%
Evening chronotype only[a]	111	25.1%	81	27.5%	30	20.4%
Sleep-disordered breathing only[b]	67	15.2%	57	19.3%	10	6.8%
Evening chronotype and sleep-disordered breathing[c]	14	3.2%	11	3.7%	3	2.0%

[a]Athletes with evening chronotype and clinical sleep problem category below moderate, and no sleep-disordered breathing. [b]Athletes with sleep-disordered breathing, clinical sleep problem category below moderate, and not evening chronotype. [c]Athletes with evening chronotype, sleep-disordered breathing, and clinical sleep problem category below moderate. Percentages are out of the total 442 athletes indicated for further assessment by physician.

Table 7—Factors associated with SDS.

	Coeff.	SE	*P*-value	95% CI
Chronotype***	−0.228	0.034	.000	−0.295 to −0.161
Completed one or more years of college***	0.589	0.162	.000	0.270 to 0.908
Degree of caffeine use*	0.311	0.123	.011	0.071 to 0.552
Reports travel related sleep disturbance***	1.668	0.189	.000	1.297 to 2.038
Reports sleep-disordered breathing	0.417	0.244	.088	−0.624 to 0.897
NCAA division 1 athlete	0.148	0.205	.471	−0.254 to 0.551
Sex	0.120	0.166	.468	−0.204 to 0.445

R^2 = .149. Multiple linear regression was used to determine factors associated with differences in SDS (n = 1,055). Factors included were selected based on statistically significant associations with SDS indicated by univariate analyses. More evening chronotype (P < .001), reporting of travel-related sleep disturbance (P < .001), greater caffeine consumption (P = .011), and having completed at least one year of college (P < .001) were found to be associated with greater sleep difficulty as measured by SDS. For statistical significance *indicates $P \leq .05$ and ***indicates $P \leq .001$. CI = confidence interval, NCAA = National College Athletic Association, SE = standard error.

conducted first, indicating that sport, body mass index, napping habits, electronic device usage before bed, specific school attended, and participation in a contact sport were not associated with statistically significant differences in SDS. A multiple linear regression model was then constructed with factors revealed by univariate analyses to be associated with statistically significant differences in SDS, including chronotype, sex, reporting of sleep-disordered breathing, reporting of travel-related sleep disturbance, degree of caffeine consumption, whether the athlete played a division 1 sport, and whether the athlete had completed at least one year of college (**Table 7**). Of these factors, more evening-chronotype students ($P < .001$), those reporting travel-related sleep disturbance ($P < .001$) and greater caffeine consumption ($P = .011$), and those who had completed at least one year of college ($P < .001$) were associated with greater sleep difficulty as measured by SDS.

DISCUSSION

Adequate sleep is critical to maintenance of physical and mental health in all persons. In competitive athletes, sleep is arguably even more essential, in order to maintain optimal sports performance and recovery. Several studies have demonstrated direct links between sleep quality and quantity to both sports performance and rates of injury.[14–19] Relative to the general population, athletes may furthermore be at higher risk of poor sleep health due to frequent travel, musculoskeletal pain, increases in core temperature following intense exercise, demanding training schedules, and psychological stress related to competition.[2,5,6,16,18,20,21] A number of recent studies have shown that athletes frequently suffer from inadequate sleep and in general have suboptimal sleep-related health.[1–11] However most of these studies have been conducted on relatively small, homogeneous samples, and have used various methods to evaluate sleep health that were not specific to athletic populations.

In contrast, the present study evaluated the sleep health of a large, diverse sample of college athletes. Furthermore, this study utilized the only clinically validated screening tool for evaluating sleep health specifically in athletes, the ASSQ. The development of the ASSQ was first reported by Samuels et al, who aimed to develop an efficient and economical screening tool to detect clinically meaningful sleep problems in athletes.[5] The clinical validation of the ASSQ was later reported by Bender et al, who found that the ASSQ, when properly scored, showed high agreement with the recommendations of a sleep medicine physician (Cohen's kappa = 0.84), with sensitivity of 81%, specificity of 93%, positive predictive value of 87%, and negative predictive value of 90%.[1] Bender et al also found that the ASSQ had good reliability by internal consistency (Cronbach's alpha = 0.74) and test-retest reliability (r = .86).[1]

The present study applied the ASSQ and validated scoring method to a population of over 1,000 college athletes participating in 15 different sports and attending 4 different National College

Athletic Association institutions. It was found that a substantial portion of college athletes have poor sleep health. Over 65% of athletes were found to have sleep health that could be considered suboptimal, scoring above none in the clinical sleep problem category rating. Moreover, nearly a quarter of athletes (23.7%) were found to have clinically meaningful problems with their sleep, with an SDS score placing them in the moderate or severe clinical sleep problem categories. No significant differences were found between different sports, suggesting that the ASSQ may be suitable for evaluating a wide range of different athletes, or that no particular sport was more associated with sleep difficulties than others. Female athletes were slightly more likely to report greater sleep difficulty, with a mean SDS of 6.0 out of 17, whereas mean SDS for male athletes was 5.7 out of 17. However, it is possible this difference may be driven more by substantial heterogeneity between male and female subgroups, and there was also slightly more variation in SDS among female athletes, with a standard deviation of ±2.9 vs ±2.6 for males, and there was also slightly more variation in SDS among female athletes, with a standard deviation of ±2.9 vs ±2.6 for males. Additionally, multivariate analysis suggested that sex was not as significant a predictor of greater sleep difficulty than other factors, including greater consumption of caffeine, evening chronotype, and travel-related sleep disturbance. The greatest difference in SDS between subgroups was found between athletes who were entering their first year of college and athletes who had completed at least one year of college. Athletes who had completed at least one year of college reported substantially greater sleep difficulty, with a mean SDS of 6.3 (±2.9) vs 5.4 (±2.4) for athletes entering their first year of college. Differences between these groups in both SDS and clinical sleep problem categories were highly statistically significant ($P < .001$). These results suggest that among competitive athletes, college athletes specifically may be at high risk of poor sleep and would benefit from regular monitoring of sleep health and interventions to improve it.

These findings are concordant with prior published data involving administration of the ASSQ to 199 Canadian National Team Athletes in 23 different sports.[1] It was found that 25.1% of athletes had clinically meaningful sleep problems, categorized moderate to severe, which is nearly identical to that found in the present study (23.7%). This is an important finding, as the moderate or severe clinical sleep problem categories are the primary way athletes are identified for further assessment and have been shown to have the highest agreement with the recommendations of a sleep medicine physician in their validation study.[1] The high level of agreement between the present study and Bender et al provides further evidence that the ASSQ is a reliable and generalizable tool for identifying clinically relevant sleep issues in athletes.

Mah et al also recently reported on sleep health in 628 college athletes, surveyed using the PSQI and Epworth Sleepiness Scale.[4] It was similarly found that a large portion of college athletes suffer from poor sleep, with 42.4% reporting PSQI scores above global averages and 51% reporting high levels of daytime sleepiness on the Epworth Sleepiness Scale. In that study, teen student athletes in their first and second years of college had the highest levels of daytime sleepiness. This is concurrent with the findings of the present study, in which a dramatic and statistically significant increase in mean SDS was observed between athletes who were entering college (mean SDS of 5.4) and athletes who had completed 1 and 2 years of college (mean SDS of 6.3). SDS was then slightly lower among athletes who had completed 3 years of college at 6.1 on average. Although highest mean SDS was found among athletes who had completed 4 years of college, this may be attributable to random variation, as this group was relatively small, only 16 athletes. These findings can perhaps be explained by the difficulty adjusting to new lifestyle stresses specific to college life and/or college athletics.

It should be noted that although PSQI is the most common questionnaire for evaluating sleep health,[22] it may not be suitable for athletes. It has been demonstrated that PSQI shows relatively poor agreement with the recommendations of a sleep medicine physician in athletic populations, and that it is possibly overly sensitive to sleep issues in athletes.[5,13] Therefore if PSQI is used as a screening tool in athletic populations, it may result in overutilization of resources and unnecessary expense.

The ASSQ may perform better than the PSQI for screening purposes in athletes. In addition to moderate or severe clinical sleep problem categories, Bender et al also recommended that athletes should be assessed by a physician if they had an evening chronotype or sleep-disordered breathing.[1] By these recommendations, the present study found that 42% of all surveyed athletes required referral for further assessment. Of these athletes, only approximately 57% were in a moderate or severe clinical sleep problem categories. The remaining 43% were identified for further assessment due to evening chronotype and/or sleep-disordered breathing alone, and had a clinical sleep problem category below moderate. Over 25% of athletes requiring referral for further assessment were of evening chronotype alone, without sleep-disordered breathing or a clinical sleep problem category above mild. The ASSQ may lack specificity in this subset of respondents, resulting in an overestimation of athletes with clinically relevant sleep issues. This may be due to an inaccurate assessment of chronotype, as the ASSQ's chronotype rating has not been clinically validated, unlike SDS and the corresponding clinical Sleep Problem Categories.[1] Overall these results suggest that clinical sleep problem category alone should be used to screen athletes for further assessment, until a greater clinical relevance of the ASSQs chronotype rating is validated.

Finally it was demonstrated that the ASSQ provided a quick and efficient approach to evaluation of sleep health in a large athletic population. Over 1,000 surveys were collected and were completed by each athlete in a matter of minutes. Surveys were administered during annual physicals prior to the start of the school year, adding minimal time and at no added cost. These findings, in addition to the generally poor sleep health found in college athletes, suggest that the ASSQ could have great utility for clinicians who oversee large diverse athletic programs as useful way to expediently screen athletes for clinically relevant issues with their sleep.

A primary limitation to this study was that the sample included only college student athletes. College athletes differ from other athletic populations in that they are younger, ranging from approximately age 17 to 23, may have lower year-round commitment to their sport, and are enrolled as students in college, which is an environment with unique lifestyle stressors that may affect sleep. Therefore results can be most accurately

generalized to this group only. However, a growing body of evidence indicates that the unique lifestyle stressors of college student athletes may predispose them to poor sleep health and related impairment.[23,24] Furthermore, college student athletes represent the largest population of competitive athletes, numbering at least over 500,000 men and women in the US. Greater understanding of sleep health in this population is therefore imperative. This need has been recognized by the National College Athletic Association explicitly in a recent consensus statement.[23]

The ASSQ is moreover uniquely suited to application in college athletic populations, because in many schools, 1 or 2 sports medicine physicians are required to coordinate care on limited budgets for hundreds of athletes. A rapid and economical way to evaluate sleep health, such as the ASSQ, could therefore have great utility for such clinicians who oversee large, diverse college athletic programs.

Overall, the present study provides valuable insight into the sleep health of athletes: It evaluated sleep health in a large, diverse sample of college athletes and used the only sleep health screening questionnaire clinically validated in an athletic population. A substantial portion of college athletes appear to suffer from suboptimal sleep and would likely benefit from intervention to improve their sleep health. Further research specific to the ASSQ should focus on validating the clinical relevance of non-SDS information and on developing efficient systems for referrals and follow-ups for those who screen positive. In addition more investigation is needed to determine the causes of poor sleep in athletes, as well as the most effective interventions to improve sleep health.

ABBREVIATIONS

ASSQ, Athlete Sleep Screening Questionnaire
PSQI, Pittsburgh Sleep Quality Index
SDS, Sleep Difficulty Score

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