Sex differences in factors associated with poor subjective sleep quality in athletes

Yu Kawasaki [1], Takatoshi Kasai [2,3,4] *, Natsue Koikawa [5,6], Naoko Hanazato [6], Shoko Suda [2,3], Azusa Murata [3], Rie Ozaki [1], Saki Nagai [1], Yuko Matsumura [1], Haruka Kaneko [7], Mayumi Kubo [8], Aki Osawa [9], Shuko Nojiri [10], Etsuko Ogasawara [5,6], Keishoku Sakuraba [6], Hiroyuki Daida [3], Mari Kitade [1,5], Atsuo Itakura [1]

[1]Department of Obstetrics and Gynecology, Juntendo University Graduate School of Medicine, Tokyo, Japan; [2]Cardiovascular Respiratory Sleep Medicine, Juntendo University Graduate School of Medicine, Tokyo, Japan; [3]Department of Cardiovascular Medicine, Juntendo University Graduate School of Medicine, Tokyo, Japan; [4]Sleep and Sleep-Disordered Breathing Center, Juntendo University Hospital, Tokyo, Japan; [5]Japanese Center for Research on Women in Sports, Juntendo University, Tokyo, Japan; [6]Graduate School of Health and Sports Science, Juntendo University, Chiba, Japan; [7]Department of Orthopedic Surgery, Juntendo University School of Medicine, Tokyo, Japan; [8]Department of Obstetrics and Gynecology, Juntendo University Urayasu Hospital, Chiba, Japan; [9]Department of Orthopedic Surgery, Juntendo University Urayasu Hospital, Chiba, Japan; [10]Medical Technology Innovation Center Clinical Research and Trial Center, Juntendo University, Tokyo, Japan

*Corresponding author: Takatoshi Kasai, MD, PhD

Department of Cardiovascular Medicine, Juntendo University Graduate School of Medicine

Cardiovascular Respiratory Sleep Medicine, Juntendo University Graduate School of Medicine

Sleep and Sleep-Disordered Breathing Center, Juntendo University Hospital

3-1-3 Hongo, Bunkyo-ku, Tokyo, Japan.
E-mail: kasai-t@mx6.nisiq.net

ABSTRACT

BACKGROUND: Sleep is an important recovery period for athletes. In general, women are not satisfied with their sleep quality, which is also true for female soccer players, although the reasons remain to be elucidated. This study aimed to confirm sex difference in sleep quality among athletes from various fields of sport, and to investigate factors related to poor subjective sleep quality in male and female athletes.

METHODS: We collected data concerning subjective sleep quality, measured by Pittsburgh Sleep Quality Index (PSQI), from athletes who were 16 to 40 years of age and played various types of sports. Data concerning their sports, lifestyle, and sleep issues and sleep environments, and also menstrual issues for females, were collected.

RESULTS: Data from 207 male athletes and 215 female athletes were assessed. Among them, 31.4% of men and 48.8% of women had poor subjective sleep quality (i.e., PSQI ≥6). In male athletes, witnessed apnea, episodes of disorientation or confusion during the time of sleep, long time gap between dinner and bedtime, and turning on the heating in the winter, were identified as factors associated with poor sleep quality by multivariate analysis, whereas in female athletes, bathing close to bedtime, habitual drinking, and being annoyed by noises at bedtime were identified.

CONCLUSIONS: In both populations, females had poorer subjective sleep quality than males. Sex differences exist in factors associated with poor subjective sleep quality. Thus, different approaches should be considered to improve their sleep quality.

Key words: Sex differences, menstruation, quality of life, sleep disorders, sports

TEXT

Introduction

Sleep plays crucial roles for recovery following exercise[1, 2] and, therefore, athletes should take the importance of sleep into account. However, studies in which scientific aspects of sleep in athletes were investigated are limited.[3, 4] In general, women are more likely to be dissatisfied with the quality of their sleep,[5, 6] though the reasons for this remain to be elucidated and may be multifactorial. According to a systematic review regarding sleep quality in athletes, 38% to 57% athletes were found to have a poor subjective sleep quality, while female and aesthetic athletes were more likely to have a poor subjective sleep quality when compared with their counterparts.[7] A recent report suggested that there is a gender difference in factors that are associated with a poor subjective sleep quality.[8] However, these study reports were not focused on investigating the presence of gender differences in the subjective sleep quality among athletes. If there is a gender difference in the sleep quality of the athletes and in factors associated with a poor subjective sleep quality, different approaches to male and female athletes may be needed to manage their sleep. In a previous study, our group compared the subjective sleep quality between male and female collegiate soccer players, and found that female collegiate soccer players had a poorer subjective sleep quality than their male counterparts.[9] Considering that women generally report a deficiency in their sleep quality when compared to men, [5, 6] and given that sleep problems are more prominent following menopause and that menstrual abnormality is pretty common in female athletes,[10, 11] there is a possibility that female athletes have poor subjective sleep quality due to abnormal menstruation. However, in our previous study, we were unable to identify the specific factors related to the poor subjective sleep quality in collegiate soccer players because the sample size was too small. In addition, data concerning lifestyle, sleep issues and sleep environments, and menstruation in females were lacking.

Thus, we assessed subjective sleep quality in a larger sample of athletes from various fields of sport primarily aiming to compare it between males and females, and then to confirm generalizability of our previous findings. We also investigated factors related to poor subjective sleep quality, including life style, sleep habits and environment, phenomena related to sleep in male and female athletes, and menstrual issues in female athletes.

Our specific hypotheses were that female athletes are more likely to have a poor subjective sleep quality even in a study primarily aiming to investigate the gender difference in subjective sleep quality in athletes of various sports. In addition, factors associated with a poor subjective sleep quality will be different between male and female athletes, while in female athletes specifically, menstrual issues will be strongly associated with a poor subjective sleep quality.

Materials and methods

Participants

Male and female athletes were recruited through advertisement. The inclusion criteria were as follows: males and females who regularly participate in competitive sports events, and aged 16 to 40 years. Those with known sleep disorders and/or mental disorders were excluded. Participants of our previous study [9] were not enrolled in the present study. The study was approved by the Research Ethics Committee of Juntendo University. Informed consent was obtained from all participants.

Data collection

We collected characteristics of participants including age, sex, body mass index (BMI), medical history, type of sport (individual or group), competition level, years of sports experience, hours of training and/or practice per day, and days of training and/or practice per week. For female athletes, self-reported information about menstruation was also collected. In this study, menstrual abnormality was defined as a menstruation cycle out of the normal range; participants were categorized as having menstrual abnormality if their menstrual cycle did not occur every 25-38 days for 3-7 days, symptoms associated with menstruation which do not interfere with daily life, according to the definition by the Japanese society of obstetrics and gynecology. We collected the following life style-related factors: habitually (i.e., almost everyday) skipping breakfast, habitually eating snacks, habitually consuming caffeine-containing beverages, habitually drinking alcoholic beverages, going to bed many hours after dinner, habitually napping (≥30 min), and bathing close to bedtime (within 2 hours). With regard to sleep environment related factors, we determined whether they slept alone, used an air-conditioner in the summer, turned on the heating in the winter, slept with the light on, used a lightproof curtain in the bedroom, felt annoyed by noises at bedtime, what type of sleep wear they wore (e.g., pajamas), and whether thoughts that their bedding items do not match occurred. Participants reported the following sleep-related phenomena: snoring, witnessed apneas during sleep, leg twitching or jerking during sleep, and episodes of disorientation or confusion during the sleeping period.

Subjective sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was used to assess subjective sleep quality in all participants.[12] The PSQI was translated into Japanese and validated by Doi and colleagues,[13] and is used to evaluate sleep quality and disturbances over a 1-month period based on self-reported information. The scale comprises 19 individual items and 7 “component” scores. Scores on each item of the index vary between 0 and 3. The total score of the seven components range from 0 to 21; a total score ≥6 indicates poor sleep quality.[12, 13] The components of the PSQI include subjectively reported sleep duration and total time spent in bed. Habitual sleep efficiency was determined based on subjectively reported sleep duration and time spent in bed.

Subjective sleepiness

The Epworth Sleepiness Scale (ESS)[14] is an established tool for evaluating subjective sleepiness. Respondents indicate the chances of falling asleep in various active and passive situations, scoring the likelihood from 0 (no chance) to 3 (high chance). The ESS had been translated into Japanese (JESS, Japanese version of the ESS) and validated by Takegami and colleagues.[15] In this study, the JESS was used to evaluate the subjective sleepiness of male and female athletes, and significant subjective sleepiness was defined as a JESS score of ≥11.

Quality of life

We used a generic health survey, short form (SF)-8™, which consists of 8 items to assess health-related quality of life (QOL) over a 1-month period; it has been translated into Japanese and validated by Fukuhara and colleagues.[16-18] This scale comprises eight subscales, including physical functioning (PF), role limitations due to physical problems (role-physical, RP), bodily pain (BP), general health perception (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (role-emotional, RE), and mental health (MH). Physical aspects of health-related QOL and mental and psychological aspects of health-related QOL are assessed through the physical component summary (PCS) and mental component summary (MCS) scores, respectively. These scores are calculated by weighting each subscale.[18] Scoring is based on Japanese standards (Japanese norm-based scoring compared with standardized Japanese scores); possible scores range from 0 to 100, with higher scores indicating a better QOL.[18]

Statistical analysis

Continuous variables were summarized using mean ± SD or median (interquartile range) as appropriate. Categorical variables are shown as percentages. Variables of male and female athletes were compared using Student's *t* test or the Mann-Whitney *U* test (if the variables were non-normally distributed) for continuous variables, and the Chi square test or Fisher's exact test for categorical variables. Female/male athletes were classified into two groups; those with and those without poor sleep quality (i.e., PSQI score ≥6) and then all variables were compared between the two subgroups of each sex group using Student's *t* test or the Mann-Whitney *U* test (if the variables were non-normally distributed) for continuous variables, and the Chi square test or Fisher's exact test for categorical variables. Effect sizes were calculated based on Cohen's d and φ. Univariate and multivariate logistic regression analyses were undertaken to assess associations between poor sleep quality and characteristics of participants, lifestyle, sleep environment factors, and sleep-related phenomena. Variables whose *P* values were found to be <0.10 in the univariate analyses were included in the multivariate analysis. Interactions between each variable were verified. A *P* value of <0.05 was considered to be statistically significant. All analyses were conducted using SPSS version 23 (SPSS Inc., Chicago, IL, USA), and G*Power 3.1.9.4 (Heinrich Heine Universitat, Dusseldorf, Germany) was used for power analysis.

Results

Characteristics of participants

Overall, 209 male athletes and 242 female athletes were targeted. Of these, the data of 2 males and 27 females could not be used for analyses as they were missing. Thus, 207 male athletes (soccer, basketball, volleyball, rugby, American football, judo, swimming, gymnastics, and track & field) and 215 female athletes (soccer, basketball, volleyball, rugby, swimming, gymnastics, track & field, karate, kendo, tennis, baton twirling, squash, classical ballet, and hip-hop dancing) were enrolled. The statistical power to detect a difference in the proportion of athletes with poor subjective sleep quality between the two genders was 94.8% based on a given sample (207 males and 215 females) and effect sizes (0.8) with an alpha of 0.05. In addition, the statistical power to detect a difference in PSQI scores was 84% based on a given sample and effect sizes (0.4) with an alpha of 0.05. Female athletes had significantly lower BMIs, were less likely to be an athlete in the national convention level, and reported shorter daily training sessions compared with males. In addition, female athletes were more likely to eat snacks compared with male athletes. However, there were no differences in drinking alcoholic beverages. The sleep duration of female athletes was shorter than that of male athletes, despite the fact that the number of male and female participants that snored, experienced witnessed apnea, and habitually napped was similar. In addition, female athletes were more likely to have leg twitching or jerking during sleep, take a bath within 2 hours of going to bed, and sleep in a single room (Table I).

Subjective sleep quality, sleepiness, and QOL in athletes

Female athletes had significantly greater PSQI scores than male athletes, indicating that females were more likely to have poor sleep quality than males (48.8% of females and

31.4% of males, $P < 0.001$; Fig. S1 A and B). In addition, female athletes had significantly greater ESS scores than male athletes and, thus, females were more likely to have subjective sleepiness than males (54.3% of females and 43.0% of males, $P = 0.025$). Based on the health-related QOL assessment using SF-8^{TM}, scores for two of the eight subscales (GH and MH) were significantly lower in female athletes compared to male athletes, and consequently, MCS scores were significantly lower in female athletes compared to male athletes (Figure 1).

Factors associated with poor subjective sleep quality in athletes

In the univariate logistic regression analyses, variables associated with poor subjective sleep quality (i.e., $P < 0.1$) were as follows: the female sex, older age, medical history, shorter sleeping duration, lower habitual sleep efficiency, sleeping with the light on, snoring, witnessed apnea, legs twitching or jerking during sleep, episodes of disorientation or confusion during sleeping time, habitual napping, bathing within 2 hours of going to bed, habitual drinking of alcoholic beverages, isolated bedroom, being annoyed by noises at bedtime, and thinking that bedding items do not match (Table SI). These variables were included in the multivariate logistic regression analysis and the female sex, shorter sleeping duration, lower habitual sleep efficiency, sleeping with the light on, being annoyed by noises at bedtime, witnessed apnea, episodes of disorientation or confusion during the sleeping period, and drinking alcoholic beverages were significantly associated with poor subjective sleep quality (Table SI).

Characteristics of male athletes with and without poor subjective sleep quality

Characteristics of male athletes with and without poor subjective sleep quality are shown in Table II. Male athletes with poor sleep quality had lower sleep efficiency, were more likely to have witnessed apnea, and episodes of disorientation or confusion during the sleeping period compared with those without poor sleep quality. In addition, male athletes with poor sleep quality are more likely to be thinking about their unmatched bedding, and be more annoyed by noises at bedtime compared with those without poor sleep quality.

Subjective sleep quality, sleepiness, and QOL in male athletes with and without poor sleep quality

Male athletes with poor sleep quality had significantly greater PSQI scores than those without poor sleep quality by definition (median interquartile range [IQR] PSQI score, 7.0 [2.0] in male athletes with poor sleep quality and 3.0 [2.0] in those without poor sleep quality; $P < 0.001$). There was no significant difference in ESS scores between the two groups and the number of participants that experience sleepiness was similar (median [IOR] ESS score, 10.0 [5.0] in male athletes with poor sleep quality (49.2%) and 10.0 [5.0] in those without poor sleep quality (40.1%); $P = 0.153$ and $P = 0.282$, respectively). Based on the health-related QOL assessment, scores for four of the eight subscales (GH, VT, MH and RE) were significantly lower, and consequently, MCS scores were significantly lower in males with poor sleep quality compared with those without (Figure 2).

Factors associated with poor subjective sleep quality in male athletes

In the univariate logistic regression analyses, the variables associated with poor sleep quality were as follows: lower sleep efficiency, witnessed apnea, episodes of disorientation or confusion during the sleeping period, long time gap between dinner and bedtime, turning on the heating in the winter, sleeping with the light on, being annoyed by noises at bedtime, and thinking that their bedding items do not fit (Table III). These variables were included in the multivariate logistic regression analysis and the following were significantly associated with poor sleep quality: lower sleep efficiency, witnessed apnea, episodes of disorientation or confusion during the time of sleep, long time gap between dinner and bedtime, and turning on the heating in the winter (Table III).

Characteristics of female athletes with and without poor subjective sleep quality

Characteristics of female athletes with and without poor subjective sleep quality are shown in Table IV. Female athletes with poor subjective sleep quality were older than those without poor sleep quality. Menstrual abnormality was more often reported in female athletes with poor sleep quality compared with those without. To be more specific, menostaxis and dysmenorrhea were significantly more frequent in the female athletes with poor sleep quality than those without (menostaxis, 10.3% in female athletes with poor sleep quality and 1.1% in those without poor sleep quality, P = 0.021; dysmenorrhea, 31.3% and 15.1%, respectively, P = 0.014). On the other hand, there were no statistically significant differences in menstrual cycle abnormality and amenorrhea between the two groups (menstrual cycle abnormality, 47.6% in female athletes with poor sleep quality and 39.3% in those without poor sleep quality, P = 0.276; amenorrhea, 21.9% and 22.9%, respectively, P = 0.987). Female athletes with poor sleep quality are more likely to be habitually drinking alcoholic beverages than those without. Female athletes with poor sleep quality have lower sleep efficiency than those without. In addition, female athletes with poor sleep quality are more likely to snore and experience episodes of disorientation or confusion during the time of sleep compared with those without poor sleep quality. Significantly more female athletes with poor sleep quality slept in a single room, with the light on, had thoughts that their bedding did not match, and felt annoyed by noises at bedtime.

Subjective sleep quality, sleepiness, and QOL in female athletes with and without poor sleep quality

Female athletes with poor sleep quality had significantly greater PSQI scores than female athletes without poor sleep quality by definition (median [IQR] PSQI score, 7.0 [3.0] in female athletes with poor sleep quality and 4.0 [2.0] in those without poor sleep quality, $P < 0.001$). Female athletes with poor sleep quality had significantly greater ESS scores than those without (median [IQR] ESS score, 12.0 [5.0] in female athletes with poor sleep quality and 10.0 [6.0] in those without poor sleep quality, $P < 0.001$). Thus, female athletes with poor sleep quality were more likely to have subjective sleepiness than those without (65.7% and 45.5%, respectively, $P = 0.004$). Based on the health-related QOL assessment, scores for seven of the eight subscales (GH, PF, RP, VT, SF, MH, and RE) were significantly lower in female athletes with poor sleep quality compared with those without (Figure 3). Consequently, MCS scores were significantly lower in female athletes with poor sleep quality compared with those without (Figure 3).

Factors associated with poor subjective sleep quality in female athletes

In the univariate logistic regression analyses, the variables associated with poor sleep quality in female athletes, were as follows: older age, menstrual abnormality, lower sleep efficiency, snoring, episodes of disorientation or confusion during the time of sleep, habitual napping, taking a bath within 2 hours of going to bed, drinking alcoholic drinks, sleeping in isolation, environmental noise, and uncomfortable bedding (Table V). These variables were included in the multivariate logistic regression analysis and menstrual abnormality, poorer habitual sleep efficiency, bathing close to bedtime, and habitual drinking alcoholic beverages, and being annoyed by noises at bedtime were significantly associated with poor sleep quality (Table V).

Discussion

The findings of this study extend the results of our previous study on sex differences in subjective measures of sleep and health-related QOL in collegiate soccer players.[9] Here we showed that in athletes from various fields of sport, female athletes slept less and felt significantly sleepier, and had poorer subjective sleep quality and health-related QOL compared with male athletes. In addition, a significant association between the female sex and poor sleep quality was confirmed even after adjusting for other confounding factors, including lifestyle-related factors, sleep environment related factors and sleep-related phenomena. Furthermore, the present study provides novel insights into sex-specific factors associated with poor subjective sleep quality. In male athletes, low sleep efficiency, witnessed apnea, episodes of disorientation or confusion during sleep, long time gap between dinner and bedtime, and turning on the heating in the winter are associated with subjective poor sleep quality. On the other hand, in female athletes, low sleep efficiency, habitual drinking, bathing within 2 hours of going to bed, disruption by outside noise, and experiencing abnormal menstruation are associated with subjective poor sleep quality. Findings of the present study are basically in line with those in our previous study.[9] However, the extent of difference in subjective sleep quality between sexes was smaller in the present study mainly because of the inclusion of more male athletes with poor sleep quality; we included overweight male athletes such as rugby players, American football players, and judo wrestlers who were more likely to have poor sleep quality due to sleep apnea (SA). Furthermore, Hoshikawa et al. reported that the female sex was not significantly associated with poor sleep quality as assessed by PSQI in a multivariable analysis, even though PSQI scores were slightly greater in female athletes compared with male athletes (4.7±2.2 versus 4.2±2.1, $P < 0.01$) and the female sex was significantly associated with poor sleep quality in the univariable analysis.[8] However, it is noteworthy to highlight that the female athletes in

Hoshikawa's study were elite athletes (candidates for the 17th Asian games Incheon 2014), who were over 20 years old. Thus, these differences in findings are probably due to the wider variation between the participants of this study and those studies. In addition, in this study we gathered a considerable amount of lifestyle-related factors, sleep environment related factors, and sleep-related phenomena, many of which were lacking in Hoshikawa's study, and some of these may have acted as confounding factors. Nevertheless, we confirmed that health-related QOL is significantly impaired in the female athletes as observed in our previous study, even though the difference in subjective sleep quality in this study is smaller. In our previous study, factors related to poor subjective sleep quality that were specific to the male or the female athletes were not identified, because the small sample size was too small. In general, no sex-specific data regarding factors associated with poor subjective sleep quality are available. However, in the present study, several factors including witnessed apnea, episodes of disorientation or confusion during sleep, longer time gap between dinner and bedtime, and turning on the heating in the winter, were identified in male athletes. These findings are particularly important because they may be used to screen for poor subjective sleep quality in athletes, and because they could serve as important interventional targets. Witnessed apnea can be suggestive of subclinical SA, which is particularly important in overweight male athletes as it impairs their quality of sleep, and it is associated with daytime sleepiness and decline in concentration, all of which may affect daytime performance. George and colleagues reported that prevalence of SA in professional American football players is around 14%, which is greater than that in men of similar age in the general population.[19] In addition, SA was found in 11 out of 23 Japanese Sumo wrestlers (47.8%).[20] Benton and colleagues reported that treatment of SA, such as continuous positive airway pressure, enhanced performance in golfers[21]; this suggests that SA can impair an athlete's performance and that this may be reversed through improving the quality of sleep by using effective therapy against SA. Taken together, in male athletes, early detection and initiation of specific treatment for SA is important for not only improving sleep quality but also performance of any sport. Episodes of disorientation or confusion during sleep may suggest the presence of parasomnias. In general, sleep deprivation and biological psychosocial stress are common risk factors for parasomnias.[22] Therefore, since athletes experience extreme stress on a daily basis, it can be presumed that athletes are more prone to parasomnias. In addition, it is likely that parasomnias are more prominent in males than females.[23] Furthermore, episodes of disorientation or confusion during sleep may be manifestations of poor sleep quality, which means that such episodes occur as a consequence of poor sleep quality and are not the cause of it. In male athletes, episodes of disorientation or confusion during sleep may be a sign that they require a sleep study and/or psychological support. In general, a late dinner may negatively affect sleep. Indeed, Hsieh and colleagues reported that a late dinner (after 9 pm at least once per week on a regular basis) is one of the causes of a short sleep duration and poor sleep quality.[24] Interestingly, our results showed the opposite to be true for male athletes: an early dinner, rather than a late one, negatively affected their sleep quality. One possible explanation for this may be that when the blood glucose level declines during sleep, excitatory hormones such as adrenaline and cortisol are secreted to raise blood glucose level, and consequently, sleep quality deteriorates and night sweats, bruxism, nightmares,[25, 26] and increased alerting responses leading to arousal from sleep also occur.[27] In fact, in patients with diabetes, even non-severe nocturnal hypoglycemic events negatively affected their overall sleep quality.[28] Because athletes generally have a high percentage of skeletal muscle and a high basal metabolism rate, which are more prominent in male athletes than female athletes, it is likely that their blood glucose drops to a low level during sleep. Although further studies that can identify the best time to have dinner in the context of sleep quality will be required, male athletes who have poor subjective sleep quality should reconsider the timing of their dinner and their bedtime. The thermal environment is one of the important factors for sleep.[29] A report suggests that an increase in evening temperature from 10 °C to 25 °C was associated with shorter sleep onset latency.[30] Generally, males are more likely to feel cold than females.[31, 32] Thus, it may be more important for male athletes to keep the room temperature around bedtime warm by any means.

In terms of female athletes, different factors from male athletes, including habitual drinking, bathing within 2 hours of going to bed, disruption by outside noise, and experiencing menstrual abnormality were identified as being associated to poor subjective sleep quality. Drinking alcohol causes a reduction in sleep onset latency but a more consolidated sleep period during the initial sleep cycles. In the later sleep cycles, however, it increases sleep disruption,[33] which in turn leads to poor sleep quality. Moreover, it has been shown that athletes with poor subjective sleep quality may be likely to drink alcohol, and although significantly less female athletes habitually drink alcohol compared with male athletes in this study, a relationship between drinking alcohol and poor sleep quality may become prominent in female athletes. However, all athletes, especially those who have poor subjective sleep quality, should avoid drinking alcohol as it impairs recovery and adaptation to training, as well as athletic performance.[34] Regarding the relationship between bathing and sleep, some reports suggest that bathing before sleep increases the percentage of slow wave sleep in the first half of sleep,[35] reduces frequency of body movements during sleep in both young and elderly participants, and enhances the quality of sleep.[36] Inagaki et al. reported that bathing 2 hours before going to bed is the best time for a good night's sleep.[37] However, the best time to bath is still under discussion, and no sex-specific data are available. Our findings suggest that bathing at least 2 hours before going to bed seems to be important for subjective sleep quality in female athletes, which is basically in line with Inagaki's findings. Hearing noises around bedtime has been shown to fragment sleep, reduce sleep continuity, and reduce total sleep duration.[38, 39] Although details of the noise, e.g., volumes and types, etc. were not investigated, and noise issues are highly subjective and can be affected by underlying insomnia, interventions for noise issues on an individual basis are worth considering.

Previous data suggested that women with menstrual abnormality had significantly worse subjective sleep quality compared with women without menstrual abnormality.[40] A report suggests that sleep onset latency was longer and sleep efficiency was lower in participants with severe dysmenorrhea than in those with mild dysmenorrhea, and females with mild dysmenorrhea reported significantly better sleep quality than those having moderate or severe dysmenorrhea.[41] Our results are basically in line with these findings which are not specifically focused on athletes. As reported by Japan Institute of Sports Sciences (JISS), in female athletes, menstrual abnormality is common and previous data suggested that 40.7% of female athletes have menstrual abnormality and 19.1% of them have amenorrhea. The high incidence of menstrual abnormality in female athletes is generally due to the lack of energy balance between dietary energy intake and exercise energy consumption.[42] Therefore, the first option to improve poor subjective sleep quality in association with menstrual abnormality is to improve the energy balance, and hormonal therapy (i.e., oral contraceptives and low dose estrogen progestin) should be considered as a second line intervention in female athletes. However, whether treatment of menstrual abnormality in female athletes improves their sleep quality remains to be elucidated. However, because menstrual abnormality in young female athletes can affect future pregnancy, our findings suggest that female athletes with menstrual abnormality need to see a gynecologist, and also a sleep specialist in an effort to improve their poor sleep quality.

Our study is subject to some limitations. First, we assessed athletes using subjective measures, and no objective measurements were considered. Therefore, it is unknown whether a discrepancy might exist between subjective and objective measures of sleep quality in athletes. Second, we did not have actual information regarding the presence or absence of sleep disorders and/or SA. Third, the data regarding lifestyle-, sleep environment related factors, and sleep-related phenomena were collected based on survey questionnaires, which were not formally validated, thus analyses regarding factors related to poor subjective sleep quality are exploratory in nature, to generate further hypotheses. Fourth, because we did not specify the timing for gathering the data, the phase of the menstrual cycle might affect answers to PSQI and SF-8. Since these are generally used to assess subjective sleep quality and quality of life over a 1-month period, further studies that use questionnaires assessing the sleep quality and quality of life over a shorter period will be needed. Finally, we did not assess athletic performance as it is impossible to do so for a group of participants from various fields of sport.

Conclusions

We have shown that female athletes had poorer subjective sleep quality, more sleepiness, and more impaired health-related QOL than male athletes. Because sex-specific factors associated with poor subjective sleep quality were identified, the development of specific intervention for male and female athletes should be considered.

REFERENCES

1. Myllymaki T, Rusko H, Syvaoja H, Juuti T, Kinnunen ML, Kyrolainen H. Effects of exercise intensity and duration on nocturnal heart rate variability and sleep quality. Eur J Appl Physiol. 2012 Mar;112(3):801-9.

2. Samuels C. Sleep, recovery, and performance: the new frontier in high-performance athletics. Neurol Clin. 2008 Feb;26(1):169-80; ix-x.

3. Simpson NS, Gibbs EL, Matheson GO. Optimizing sleep to maximize performance: implications and recommendations for elite athletes. Scand J Med Sci Sports. 2017 Mar;27(3):266-74.

4. Leeder J, Glaister M, Pizzoferro K, Dawson J, Pedlar C. Sleep duration and quality in elite athletes measured using wristwatch actigraphy. J Sports Sci. 2012;30(6):541-5.

5. Akerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Sleep disturbances, work stress and work hours: a cross-sectional study. J Psychosom Res. 2002 Sep;53(3):741-8.

6. Lindberg E, Janson C, Gislason T, Bjornsson E, Hetta J, Boman G. Sleep disturbances in a young adult population: can gender differences be explained by differences in psychological status? Sleep. 1997 Jun;20(6):381-7.

7. Gupta L, Morgan K, Gilchrist S. Does Elite Sport Degrade Sleep Quality? A Systematic Review. Sports Med. 2017 Jul;47(7):1317-33.

8. Hoshikawa M, Uchida S, Hirano Y. A Subjective Assessment of the Prevalence and Factors Associated with Poor Sleep Quality Amongst Elite Japanese Athletes. Sports Med Open. 2018 Feb 26;4(1):10.

9. Koikawa N, Shimada S, Suda S, Murata A, Kasai T. Sex differences in subjective sleep quality, sleepiness, and health-related quality of life among collegiate soccer players.

Sleep Biol Rhythms. 2016;14(4):377-86.

10. De Souza MJ, Nattiv A, Joy E, Misra M, Williams NI, Mallinson RJ, et al. 2014 Female Athlete Triad Coalition Consensus Statement on Treatment and Return to Play of the Female Athlete Triad: 1st International Conference held in San Francisco, California, May 2012 and 2nd International Conference held in Indianapolis, Indiana, May 2013. Br J Sports Med. 2014 Feb;48(4):289.

11. Kravitz HM, Zhao X, Bromberger JT, Gold EB, Hall MH, Matthews KA, et al. Sleep disturbance during the menopausal transition in a multi-ethnic community sample of women. Sleep. 2008 Jul;31(7):979-90.

12. Buysse DJ, Reynolds CF, 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989 May;28(2):193-213.

13. Doi Y, Minowa M, Uchiyama M, Okawa M, Kim K, Shibui K, et al. Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J) in psychiatric disordered and control subjects. Psychiatry Res. 2000 Dec 27;97(2-3):165-72.

14. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep. 1991 Dec;14(6):540-5.

15. Takegami M, Suzukamo Y, Wakita T, Noguchi H, Chin K, Kadotani H, et al. Development of a Japanese version of the Epworth Sleepiness Scale (JESS) based on item response theory. Sleep Med. 2009 May;10(5):556-65.

16. Fukuhara S, Bito S, Green J, Hsiao A, Kurokawa K. Translation, adaptation, and validation of the SF-36 Health Survey for use in Japan. J Clin Epidemiol. 1998 Nov;51(11):1037-44.

17. Shaku F, Tsutsumi M, Miyazawa A, Takagi H, Maeno T. Self-care behavior when

suffering from the common cold and health-related quality of life in individuals attending an annual checkup in Japan: a cross-sectional study. BMC Fam Pract. 2015 Jul 29;16:91.

18. Fukuhara S, Suzukamo Y. Manual of the SF-8 Japanese version. Kyoto: Institute for Health Outcomes & Process Evaluation research. 2004.

19. George CF, Kab V, Levy AM. Increased prevalence of sleep-disordered breathing among professional football players. N Engl J Med. 2003 Jan 23;348(4):367-8.

20. Suzuki N. Sumorikishi ni okeru suiminji kokyu shogai no kentou (A study on sleep breathing disorder in sumo wrestlers.). Annals of the Japanese Respiratory Society. 2003;41:76.

21. Benton ML, Friedman NS. Treatment of obstructive sleep apnea syndrome with nasal positive airway pressure improves golf performance. J Clin Sleep Med. 2013 Dec 15;9(12):1237-42.

22. Fleetham JA, Fleming JA. Parasomnias. CMAJ. 2014 May 13;186(8):E273-80.

23. Inoue Y. Clinical significant of REM sleep disorder comorbid with depression. Report of the Grant-in-Aid for scientific Research (C) (no 25515009) by the Ministry of Education, Culture, Sports, Science and Technology. 2017.

24. Hsieh SD, Muto T, Murase T, Tsuji H, Arase Y. Association of short sleep duration with obesity, diabetes, fatty liver and behavioral factors in Japanese men. Intern Med. 2011;50(21):2499-502.

25. Allen KV, Frier BM. Nocturnal hypoglycemia: clinical manifestations and therapeutic strategies toward prevention. Endocr Pract. 2003 Nov-Dec;9(6):530-43.

26. Nukazawa S, Yoshimi H, Sato S. Autonomic nervous activities associated with bruxism events during sleep. Cranio. 2018 Mar;36(2):106-12.

27. Steriade M, Datta S, Pare D, Oakson G, Curro Dossi RC. Neuronal activities in brain-stem cholinergic nuclei related to tonic activation processes in thalamocortical systems. J

Neurosci. 1990 Aug;10(8):2541-59.

28. Brod M, Christensen T, Bushnell DM. Impact of nocturnal hypoglycemic events on diabetes management, sleep quality, and next-day function: results from a four-country survey. J Med Econ. 2012;15(1):77-86.

29. Gilbert SS, van den Heuvel CJ, Ferguson SA, Dawson D. Thermoregulation as a sleep signalling system. Sleep Med Rev. 2004 Apr;8(2):81-93.

30. Saeki K, Obayashi K, Tone N, Kurumatani N. A warmer indoor environment in the evening and shorter sleep onset latency in winter: The HEIJO-KYO study. Physiol Behav. 2015 Oct 1;149:29-34.

31. Wyndham CH, Morrison JF, Williams CG, Bredell GA, Peter J, Vonrahden MJ, et al. PHYSIOLOGICAL REACTIONS TO COLD OF CAUCASIAN FEMALES. J Appl Physiol. 1964 Sep;19:877-80.

32. Graham TE. Thermal, metabolic, and cardiovascular changes in men and women during cold stress. Med Sci Sports Exerc. 1988 Oct;20(5 Suppl):S185-92.

33. Ebrahim IO, Shapiro CM, Williams AJ, Fenwick PB. Alcohol and sleep I: effects on normal sleep. Alcohol Clin Exp Res. 2013 Apr;37(4):539-49.

34. Parr EB, Camera DM, Areta JL, Burke LM, Phillips SM, Hawley JA, et al. Alcohol ingestion impairs maximal post-exercise rates of myofibrillar protein synthesis following a single bout of concurrent training. PLoS One. 2014;9(2):e88384.

35. Horne JA, Reid AJ. Night-time sleep EEG changes following body heating in a warm bath. Electroencephalogr Clin Neurophysiol. 1985 Feb;60(2):154-7.

36. Kanda K, Tochihara Y, Ohnaka T. Bathing before sleep in the young and in the elderly. Eur J Appl Physiol Occup Physiol. 1999 Jul;80(2):71-5.

37. Inagaki J, Mahbud MH, Harada N. Effects of timing of warm bathing on night sleep in young healthy subjects. The bulletin of the Yamaguchi Medical School. 2007;54(1-2):9-17.

38. Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, et al. Auditory and non-auditory effects of noise on health. Lancet. 2014 Apr 12;383(9925):1325-32. PubMed PMID: 24183105.

39. Muzet A. Environmental noise, sleep and health. Sleep Med Rev. 2007 Apr;11(2):135-42.

40. Baker FC, Driver HS, Rogers GG, Paiker J, Mitchell D. High nocturnal body temperatures and disturbed sleep in women with primary dysmenorrhea. Am J Physiol. 1999 Dec;277(6 Pt 1):E1013-21.

41. Woosley JA, Lichstein KL. Dysmenorrhea, the menstrual cycle, and sleep. Behav Med. 2014;40(1):14-21.

42. Joy E, De Souza MJ, Nattiv A, Misra M, Williams NI, Mallinson RJ, et al. 2014 female athlete triad coalition consensus statement on treatment and return to play of the female athlete triad. Curr Sports Med Rep. 2014 Jul-Aug;13(4):219-32.

NOTES

Conflicts of interest.—

Drs. Takatoshi Kasai and Shoko Suda are affiliated with a department endowed by Philips Respironics, ResMed, Teijin Home Healthcare, and Fukuda Denshi. Dr. Daida received manuscript fees, research funds, and scholarship funds from Kirin Co. Ltd., Kaken Pharmaceutical Co.,Ltd., Abbott Japan Co., Ltd., Astellas Pharma Inc, Astrazeneca K.K., Bayer Yakuhin, Ltd, Boston Scientific Japan K.K., Bristol-Myers Squibb, Daiichi Sankyo Company, MSD K.K., Pfizer Inc., Philips Respironics, Sanofi K.K., and Takeda Pharmaceutical Co. Ltd. The other authors report no conflicts of interest.

Funding.—

This work was supported by the MEXT*-Supported Program for the Strategic Research Foundation at Private Universities, 2014–2018 (*Ministry of Education, Culture, Sports, Science and Technology) under Grant [Strategic Research Foundation at Private Universities, 2014-2018]; Japanese Center for Research on Women in Sport under Grant [Project 1-C]; Juntendo University Young Investigator Joint Project Award 2015 under Grant [K1517].

Authors' contributions.—

Yu Kawasaki designed the study contributed to analysis and wrote the initial draft of the manuscript. Takatoshi Kasai designed the study, contributed to analysis and interpretation of data and assisted in the preparation of the manuscript. All other authors have contributed to data collection and interpretation, and critically reviewed the manuscript. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

TABLES

Table I. —Characteristics of male and female athletes

	Males N=207	Females N=215	P	Effect size
Age, years	20.1±1.2	19.8±4.2	0.315	0.1*
BMI, kg/m^2	22.3±3.8	20.6±3.6	<0.001	0.46*
Medical history,%	57.0	48.9	0.113	0.08
Individual/group sport - group sport, %	24.2	32.0	0.092	0.09
Competition level – national or above, %	56.5	45.2	0.025	0.12
Experience, years	9.2±3.7	9.2±3.7	0.947	0*
Hours of training-practice per day, h	3.2±1.0	3.5±1.3	0.027	0.26*
Days of training-practice per week, days	5.7±0.8	5.7±1.3	0.701	0*
Skipping breakfast, %	4.8	2.3	0.249	0.07
Snack habit, %	48.3	61.2	0.010	0.13
Time from dinner to bedtime, h	4.2±1.2	4.0±1.3	0.074	0.16*
Consuming caffeinated drinks, %	34.3	35.2	0.933	0.01
Drinking alcoholic beverages, %	12.6	6.8	0.067	0.09
Sleep duration, h	7.7±1.3	7.2±1.2	<0.001	0.40*
Habitual sleep efficiency, %	91.3±9.71	92.8±9.43	0.101	0.16*
Snoring, %	18.4	11.9	0.082	0.09
Witnessed apnea, %	3.4	0.9	0.097	0.08
Legs twitching or jerking during sleep, %	26.6	36.1	0.045	0.11
Episodes of disorientation or confusion during sleeping period, %	8.7	13.2	0.180	0.07
Habitual napping, %	23.2	17.4	0.168	0.07
Bathing within 2 hours of going to bed, %	44.9	67.6	<0.001	0.23
Sleeping in a single room, %	39.3	61.9	<0.001	0.23
Use of air-conditioner in summer, %	57.6	56.8	0.954	0
Turning on the heating in winter, %	42.9	42.6	1.000	0
Sleeping with the light on, %	2.9	2.3	0.946	0.02
Use of lightproof curtain, %	66.5	63.3	0.551	0.03
Annoyed by noises at bedtime, %	26.2	24.9	0.841	0.01
Type of sleep wear - pajamas, %	35.3	42.0	0.184	0.07
Thinking that bedding items do not match, %	15.5	15.1	1.000	0.01

Continuous data are summarized using mean ±SD. *Effect sizes were assessed by Cohen’s d.
BMI body mass index

Table II. —Characteristics of male athletes with and without poor subjective sleep quality

	Without poor sleep quality (PSQI<6) N=142	With poor sleep quality (PSQI≥6) N=65	P	Effect size
Age, years	20.1±1.3	20.1±1.1	0.978	0*
BMI, kg/m^2	22.4±4.1	21.9±3.3	0.384	0.13*
Medical history,%	59.9	50.8	0.282	0.09
Individual/group sport - group sport, %	23.9	24.6	1.000	0.01
Competition level – national or above, %	54.2	61.5	0.404	0.07
Experience, years	9.4±3.7	8.8±3.6	0.307	0.16*
Hours of training-practice per day, h	3.1±1.0	3.4±1.2	0.134	0.28*
Days of training-practice per week, days	5.7±0.8	5.8±0.9	0.600	0.12*
Skipping breakfast, %	4.9	4.6	1.000	0.01
Snack habit, %	45.8	53.8	0.353	0.08
Time from dinner to bedtime, h	4.1±1.1	4.4±1.3	0.085	0.26*
Consuming caffeinated drinks, %	33.8	35.4	0.948	0.02
Drinking alcoholic beverages, %	10.6	16.9	0.291	0.09
Sleep duration, h	7.7±1.0	7.6±1.8	0.545	0.08*
Habitual sleep efficiency, %	94.3±5.59	84.8±13.1	<0.001	1.1*
Snoring, %	15.5	24.6	0.168	0.11
Witnessed apnea, %	0.7	9.2	0.004	0.22
Legs twitching or jerking during sleep, %	23.9	32.3	0.274	0.09
Episodes of disorientation or confusion during sleeping time, %	5.6	15.4	0.041	0.16
Habitual napping, %	21.1	27.7	0.389	0.07
Bathing within 2 hours of going to bed, %	45.8	43.1	0.832	0.03
Sleeping in a single room, %	41.1	35.4	0.528	0.05
Use of air-conditioner in summer, %	58.6	55.4	0.781	0.03
Turning on the heating in winter, %	38.6	52.3	0.090	0.13
Sleeping with the light on, %	1.4	6.2	0.080	0.13
Use of lightproof curtain, %	68.1	63.1	0.583	0.05
Annoyed by noises at bedtime, %	19.9	40.0	0.004	0.21
Type of sleep wear - pajamas, %	36.6	32.3	0.656	0.04
Thinking that bedding items do not match, %	11.3	24.6	0.024	0.17

Continuous data are summarized using mean ±SD. *Effect sizes were assessed by Cohen's d.
BMI body mass index

Table III. —Results of univariate and multivariate logistic regression analyses for poor sleep quality in male athletes

	Univariate		Multivariate	
	OR (95% CI)	P	OR (95% CI)	P
Habitual sleep efficiency (1% increase)	0.88 (0.85-0.92)	<0.001	0.86 (0.81-0.91)	<0.001
Witnessed apnea (yes)	14.3 (1.69-122)	0.015	61.4 (5.70-660)	0.001
Episodes of disorientation or confusion during sleeping period (yes)	3.05 (1.14-8.13)	0.026	4.47 (1.36-14.7)	0.014
Time from dinner to bedtime (1 h increase)	1.26 (0.97-1.63)	0.087	1.48 (1.06-2.08)	0.022
Turning on the heating in winter (yes)	0.57 (0.32-1.04)	0.066	0.42 (0.20-0.91)	0.027
Sleeping with the light on (yes)	4.56 (0.81-25.5)	0.085	-	-
Annoyed by noises at bedtime (yes)	2.69 (1.41-5.13)	0.003	2.08 (0.91-4.72)	0.082
Thinking that bedding items do not match (yes)	2.57 (1.19-5.54)	0.016	-	-

CI confidence interval, *OR* odds ratio

Table IV. —Characteristics of female athletes with and without poor subjective sleep quality

	Without poor sleep quality (PSQI<6) N=110	With poor sleep quality (PSQI≥6) N=105	P	Effect size
Age, years	19.0±3.5	20.3±4.4	0.010	0.34*
BMI, kg/m^2	20.2±2.6	21.1±4.4	0.077	0.28*
Medical history, %	52.7	46.7	0.452	0.06
Individual/group sport - group sport, %	35.5	27.6	0.276	0.08
Competition level – national or above, %	48.2	41.0	0.353	0.07
Experience, years	8.8±3.2	9.5±4.0	0.129	0.2*
Hours of training-practice per day, h	3.5±1.1	3.4±1.5	0.545	0.08*
Days of training-practice per week, days	5.8±1.3	5.6±1.3	0.347	0.15*
Menstrual abnormality, %	58.2	74.3	0.019	0.17
Skipping breakfast, %	0.9	3.8	0.202	0.10
Snack habit, %	56.0	66.7	0.143	0.11
Time from dinner to bedtime, h	4.0±1.2	4.0±1.4	0.960	0*
Consuming caffeinated drinks, %	30.9	41.0	0.164	0.10
Drinking alcoholic beverages, %	2.7	11.4	0.025	0.17
Sleep duration, h	7.3±1.0	7.1±1.3	0.210	0.18*
Habitual sleep efficiency, %	95.5±5.85	90.1±11.5	<0.001	0.67*
Snoring, %	7.3	17.1	0.044	0.15
Witnessed apnea, %	0.0	1.9	0.237	0.10
Legs twitching or jerking during sleep, %	34.5	39.0	0.587	0.05
Episodes of disorientation or confusion during sleeping time, %	8.2	19.0	0.033	0.16
Habitual napping, %	12.7	22.9	0.077	0.13
Bathing within 2 hours of going to bed, %	62.7	75.2	0.067	0.38
Sleeping in a single room, %	54.5	69.5	0.034	0.15
Use of air-conditioner in summer, %	55.7	57.8	0.868	0.03
Turning on the heating in winter, %	42.1	43.1	0.998	0.01
Sleeping with the light on, %	0.0	4.8	0.027	0.16
Use of lightproof curtain, %	61.8	64.8	0.760	0.03
Annoyed by noises at bedtime, %	14.7	35.6	0.001	0.24
Type of sleep wear - pajamas, %	40.0	45.7	0.479	0.06
Thinking that bedding items do not match, %	10.0	21.0	0.042	0.15

Continuous data are summarized using mean ±SD. *Effect sizes were assessed by Cohen’s d.
BMI body mass index

Table V. —Results of univariate and multivariate logistic regression analyses for poor sleep quality in female athletes

	Univariate		Multivariate	
	OR (95% CI)	P	OR (95% CI)	P
Age (1-year increase)	1.11 (1.02-1.21)	0.017	-	-
Menstrual abnormality (yes)	2.08 (1.16-3.70)	0.013	1.96 (1.01-3.80)	0.046
Habitual sleep efficiency (1% increase)	0.93 (0.89-0.96)	<0.001	0.92 (0.89-0.96)	<0.001
Witnessed snoring (yes)	2.64 (1.09-6.36)	0.031	-	-
Episodes of disorientation or confusion during sleeping time (yes)	2.64 (1.14-6.10)	0.023	-	-
Habitual napping (yes)	2.03 (0.99-4.18)	0.054	-	-
Bathing within 2 hours of going to bed (yes)	1.81 (1.00-3.25)	0.049	2.04 (1.03-4.03)	0.040
Drinking alcoholic drinks (yes)	4.60 (1.26-16.8)	0.021	4.01 (1.02-15.7)	0.046
Sleeping in a single room (yes)	0.53 (0.30-0.92)	0.025	-	-
Annoyed by noises at bedtime (yes)	3.21 (1.65-6.24)	0.001	2.43 (1.16-5.08)	0.019
Thinking that bedding items do not fit (yes)	2.40 (1.09-5.21)	0.029	-	-

CI confidence interval, *OR* odds ratio

TITLES OF FIGURES

Figure 1.—SF-8 subscales and component summary scores between male and female athletes

Female athletes showed significantly lower GH, MH, and MCS scores, while there were no significant differences for other subscales or PCS scores between male and female athletes. Values represent the median and interquartile range. *BP* = body pain, *F* = female athletes, *GH* = general health perception, *M* = male athletes, *MCS* = mental component summary, *MH* = mental health, *PCS* = physical component summary, *PF* = physical functioning, *RE* = role limitations due to emotional problems, *RP* = role limitations due to physical problems, *SF* = social functioning, *VT* = vitality

Figure 2.—SF-8 subscales and component summary scores between male athletes with and without poor sleep quality

Male athletes with poor sleep quality showed significantly lower GH, VT, MH, RE, and MCS scores, while there were no significant differences for other subscales or PCS scores between the two groups. Values represent the median and interquartile range. *BP* = body pain, *F* = female athletes, *GH* = general health perception, *M* = male athletes, *MCS* = mental component summary, *MH* = mental health, *PCS* = physical component summary, *PF* = physical functioning, *RE* = role limitations due to emotional problems, *RP* = role limitations due to physical problems, *SF* = social functioning, *VT* = vitality, *<6* = without poor sleep quality (PSQI-J <6), *≥6* = with poor sleep quality (PSQI-J ≥6)

Figure 3.—SF-8 subscales and component summary scores between female athletes with and without poor sleep quality

Female athletes with poor sleep quality showed significantly lower GH, PF, RP, VT, SF, MH, RE, and MCS scores, while there were no significant differences for other subscales or PCS scores between the two groups. Values represent the median and interquartile range. *BP* = body pain, *F* = female athletes, *GH* = general health perception, *M* = male athletes, *MCS* = mental component summary, *MH* = mental health, *PCS* = physical component summary, *PF* = physical functioning, *RE* = role limitations due to emotional problems, *RP* = role limitations due to physical problems, *SF* = social functioning, *VT* = vitality, *<6* = without poor sleep quality (PSQI-J <6), *≥6* = with poor sleep quality (PSQI-J ≥6)

Figure S1.— A) Comparison between PSQI scores of male and female athletes. B) Comparison between the proportion of male and female athletes with poor sleep quality.

A) Comparison of PSQI scores [PSQI scores were significantly greater in females compared with males ($P < 0.001$). Values represent the median and interquartile range]. B) Comparison between the proportion of male and female athletes with poor sleep quality [PSQI ≥6 indicates participants with poor sleep quality; $P < 0.001$)]. *PSQI* = Pittsburg Sleep Quality Index

Figure 1

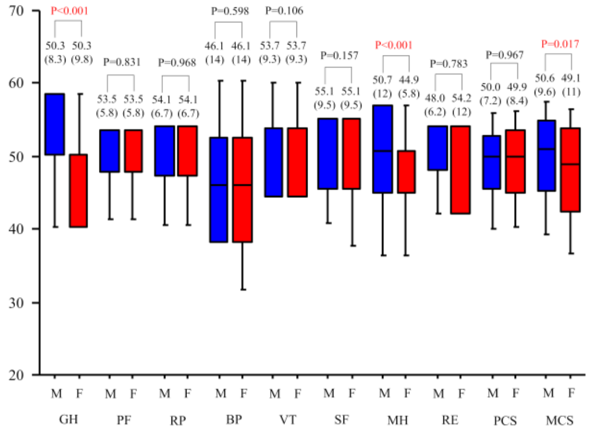

Figure 2

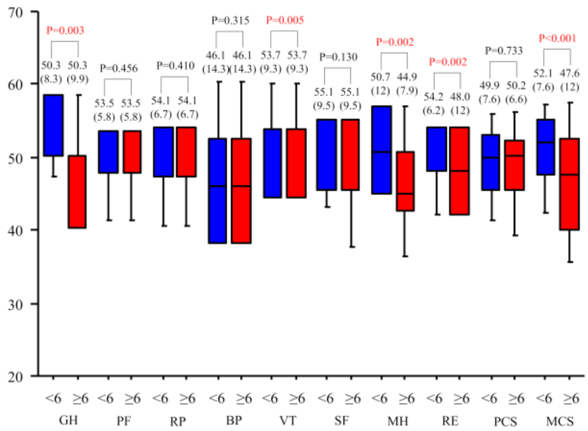

Figure 3

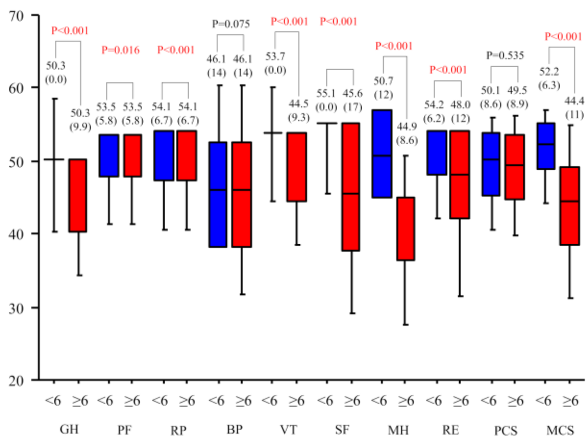

Figure S1

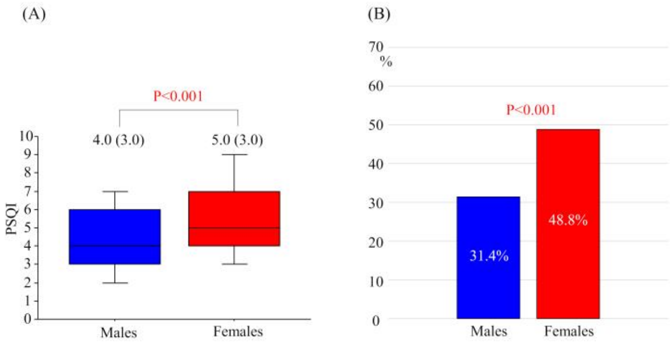
(A)
P<0.001
4.0 (3.0)
5.0 (3.0)
PSQI
10
9
8
7
6
5
4
3
2
1
0
Males
Females
(B)
70
%
60
50
40
30
20
10
0
P<0.001
31.4%
48.8%
Males
Females

Table S1-Results of univariate and multivariate logistic regression analyses for poor sleep quality in male and female athletes

	Univariate		Multivariate	
	OR (95% CI)	P	OR (95% CI)	P
Female (yes)	2.09 (1.40-3.10)	<0.001	3.30 (1.95-5.59)	<0.001
Age (1-year increase)	1.08 (1.01-1.16)	0.032	-	-
Medical history (yes)	1.41 (0.95-2.08)	0.086	-	-
Sleep duration (1 h increase)	0.85 (0.72-1.00)	0.046	0.44 (0.33-0.57)	<0.001
Habitual sleep efficiency (1% increase)	0.92 (0.89-0.94)	<0.001	0.85 (0.82-0.88)	<0.001
Sleeping with the light on (yes)	6.93 (1.48-32.5)	0.014	8.88 (1.50-52.4)	0.016
Snoring (yes)	1.85 (1.08-3.16)	0.024	-	-
Witnessed apnea (yes)	12.4 (1.54-100)	0.018	38.8 (3.51-429.7)	0.003
Legs twitching or jerking during sleep (yes)	1.44 (0.95-2.17)	0.088	-	-
Episodes of disorientation or confusion during sleeping period (yes)	2.96 (1.58-5.57)	0.001	2.38 (1.08-5.28)	0.032
Habitual napping (yes)	1.55 (0.96-2.50)	0.071	-	-
Bathing within 2 hours of going to bed (yes)	1.50 (1.01-2.23)	0.047	-	-
Habitual drinking of alcoholic beverages (yes)	2.03 (1.06-3.90)	0.032	3.50 (1.54-7.95)	0.003
Sleeping in a single room (yes)	0.68 (0.46-1.01)	0.057	-	-
Annoyed by noises at bedtime (yes)	2.78 (1.77-4.37)	<0.001	3.10 (1.76-5.46)	<0.001
Thinking that bedding items do not fit (yes)	2.40 (1.40-4.11)	0.001	-	-

CI confidence interval, *OR* odds ratio