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Regular Practice of Competitive Sports Does Not Impair Sleep in Adolescents: DADOS Study

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Purpose: To analyze differences in sleep quality and duration by athletic status and sex, and to examine the association between physical activity (PA) recommendation and sleep in adolescents. ***Methods:*** A total of 267 adolescents [13.9 (0.3) y] from Deporte, ADOlescencia y Salud (DADOS) study (129 girls) were included in this cross-sectional analysis. Athletes competed regularly in organized sport events and trained ≥3 days per week, but nonathletes did not compete. PA was assessed by GENEActiv accelerometer. PA values were dichotomized into inactive (<60 min/d of moderate and vigorous PA) and active (≥60 min/d of moderate and vigorous PA). Sleep quality was evaluated with the Spanish version of the Pittsburgh Sleep Quality Index. Pittsburgh Sleep Quality Index values were dichotomized into >5 (poor quality) or ≤5 (good quality). Sleep duration was objectively measured by accelerometer. ***Results:*** Sleep quality and duration were not statistically different between athletes [median (Mdn) = 4.0, interquartile range (IQR) = 3.0–6.0 and Mdn = 8.0, IQR = 7.4–8.6 h, respectively] and nonathletes (Mdn = 5.0, IQR = 3.0–7.0 and Mdn = 7.9; IQR = 7.3–8.6 h, respectively), $P > .05$. Nonathlete or inactive adolescents did not show higher risk for poor sleep quality or short sleep duration than athletes [odds ratio (OR) = 1.17; 95% confidence interval (CI), 0.68–2.00 and OR = 0.93; 95% CI, 0.56–1.55, respectively] or active peers (OR = 1.39; 95% CI, 0.66–2.89 and OR = 1.62; 95% CI, 0.78–3.37, respectively). ***Conclusions:*** In our group of adolescents, competitive sport practice did not alter sleep patterns. PA recommendations for adolescents may not discriminate between good and poor sleepers.

Keywords: adolescence, health, athlete, physical activity

Adolescence is a crucial period of life characterized by several psychological and physiological changes (8) and by the establishment of many health-related behaviors such as sleep (9). Adequate sleep is considered a key health factor being particularly important for optimal physical, cognitive, and emotional development during childhood and adolescence (45). Although sleep research is mostly focused on duration, sleep quality is showing even more significant health-related consequences (16,39).

Despite individual variations (31), the current sleep recommendation for adolescents is 8–10 hours of sleep per night (19). During adolescence, sleep duration and

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quality decrease, whereas sleep disturbances increase (24,27,40), female adolescents being more affected than male adolescents (4–6,24). These changes could lead to an increased risk of obesity (12), cardiometabolic risk (20), psychosocial disorders (13,18), and cognitive disturbances (28). In addition, insufficient or disturbed sleep in adolescent athletes may influence exercise recovery, performance, and injury risk (34,44).

Physical activity (PA) has been suggested to have a positive impact on sleep, improving duration and quality (23). Organized sport, which includes regular training sessions and competitions under coach supervision, is the most common practice of PA among children and adolescents (10). Recent research has highlighted the positive influence of general PA on sleep in young adults (14) and adolescents (4,5,25). However, young adult athletes have reported to experience poor sleep (26,46), but data on adolescent athletes are scarce and not conclusive (3,4).

The primary aim of this study was to analyze the differences in sleep quality and duration between athlete and nonathlete adolescents. Secondary aims were to investigate sex differences in these sleep parameters and to examine whether meeting current daily PA recommendations was related to sleep.

The following hypotheses were investigated:

1) Even though general PA has been favorably related to adolescents' sleep, young adults participating in competitive sports reported more sleep disturbances than nonathletes (26,46). Therefore, we expected to find poorer and shorter sleep among the athletes compared with nonathletes.
2) As previous data suggested higher sleep disturbances in female adolescents (4–6,24), we expected to find poorer and shorter sleep in our group of females compared with males.
3) In line with the previous research (29), we expected to find that meeting current PA recommendation for adolescents would be positively associated to sleep patterns.

Methods

Study Design and Participants

This study is part of the Deporte, ADOlescencia y Salud (DADOS) research project, a 3-year longitudinal study aimed to analyze the influence of competitive PA on health, cognition, and psychological wellness through adolescence. All participants were recruited from secondary schools and sport clubs and met the general DADOS inclusion criteria (born in 2001, enrolled in second grade of secondary school, free of any chronic disease, regularly compete in organized sport events with at least 3 training sessions per week or not regularly compete in organized sport events). The results presented in this study belong to baseline data obtained between February and May of 2015.

A total of 267 adolescents (170 athletes and 97 nonathletes) completed the baseline assessment with valid data for sleep, body composition, and accelerometry. Two questions were used to classify the participants: "Are you competing regularly in organized sport events?" and "If you are regularly competing, how many training sessions do you perform per week?" Athletes were defined as adolescents who regularly compete in organized sport events with at least 3 training sessions per week. Nonathletes were defined as adolescents who did not regularly compete in organized sport events.

After receiving complete information about the aims and methods of the study, all adolescents and their parents or guardians included in the study signed the informed written consent. The study was performed following the ethical guidelines of the Declaration of Helsinki 1961 (revision of Fortaleza 2013), and the study protocol was approved by the research ethics committee of the University Jaume I.

PA Measurement

Participants' PA level was objectively measured using the GENEActiv accelerometer (Activinsights Ltd, Kimbolton, UK), a device that contains a triaxial microelectromechanical accelerometer that records both motion-related and gravitational acceleration and has a linear and equal sensitivity along the 3 axes. Participants wore the accelerometer on their nondominant wrist for at least 4 consecutive 24-hour days, including weekends and weekdays. This device has been found to be a reliable (coefficient of variation intrainstrument = 1.4% and coefficient of variation interinstrument = 2.1%) (11) and valid objective measure of PA in young people ($r = .925$, $P = .001$) (38). Accelerometers were programmed to collect data at a sampling frequency of 100 Hz. Data were stored in gravity (g) units ($1g = 9.81\ m/s^2$). The raw acceleration output was converted to 1-second epochs using the GENEActiv postprocessing PC software (version 2.2; GENEActiv). By combining all registered days for each participant and using the Excel macro provided by the commercial brand to summarize the data, PA was expressed as average minutes per day in sedentary, light, moderate, and vigorous PA. According to Phillips et al (38), GENEActiv cut points for sedentary, light, moderate, and vigorous intensities in children are <7, 7–19, 20–60, and >60g. Moderate and vigorous PA (MVPA) was calculated by adding moderate PA and vigorous PA. Participants were categorized based on their daily MVPA level in active (≥60 min/d of MVPA) or inactive (<60 min/d of MVPA) in line with the general PA guidelines for adolescents proposed by the World Health Organization (49).

Sleep Quality and Duration

The Spanish version of Pittsburgh Sleep Quality Index (PSQI) was used to assess adolescents' sleep quality over the last month (42). It includes 19 questions in 7 components of sleep quality: subjective sleep quality, sleep duration, sleep latency, habitual sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. The 7 component scores are rated on a 3-point ascending scale, with 0 points indicating ideal sleep quality and 3 points indicating poor sleep quality. The global score of the PSQI is the sum of all component scores. The minimum possible score is 0, indicating ideal sleep quality, and the maximum possible score is 21, indicating poor sleep quality. According to Buysse et al (7), the PSQI provides a sensitive measure to identify poor sleep quality if total PSQI score is >5, comparable to clinical and laboratory measures (such as polysomnography). Therefore, we defined participants with total scores of 5 and below as "good sleepers," and those with total scores of 6 and above were defined as "poor sleepers."

Daily sleep duration was objectively measured by GENEActiv accelerometer (Activinsights Ltd). It has been found reliable to examine sleep [$\kappa = .85$ (.06)] (48). Sleep duration was calculated by the algorithm included in the macro provided by the Activinsights company based on the sum of accelerations (<7*g*) and evaluating the 60 prevalues and postvalues (120 measurement points) (43). In addition, to assist differentiation from sedentary time, participants kept a sleep log of their sleep–wake schedule to check possible inconsistencies in the accelerometer data. We observed high level of agreement between the accelerometer and the participants' sleep log data. However, when the results were discrepant, the day was removed, yet guaranteeing a measurement of at least 4 complete days for all participants analyzed. By combining all registered days for each participant, sleep duration was then expressed as average hours per day. In agreement with the American Sleep Foundation, short sleep in adolescent population is defined as sleeping less than 8 hours per night (19).

Physical Examination

Pubertal status was assessed according to the standardized Tanner stages based on external primary and secondary sex characteristics. The degree of development was self-reported by the participants using standard pictures consistent with Tanner instructions (47). Two components were assessed: pubic hair growth for boys and girls, plus breast development in girls and genital development in boys. A 5-point maturity rating was used where stage 1 corresponds to the prepubertal state and stage 5 corresponds to mature state. The highest rating of the 2 components was used for data analyses.

Weight and height were obtained with the participant in light indoor clothes and without shoes by using standard procedures as in our previous study (36). Weight was measured with an electronic scale (model 861; seca, Hamburg, Germany) to the nearest 0.1 kg. Height was measured in the Frankfort plane with a wall-mounted stadiometer (model 213; seca) to the nearest 0.1 cm. Weight and height were measured in duplicate, and the average was used for data analyses. Body mass index was calculated as weight in kilograms divided by the square of the height in meters (kg/m^2). In addition, 2 nonconsecutive measurements of waist circumference were performed at the thinnest waist diameter between the last rib bone and the superior iliac crest using a homologated flexible steel tape (Harpenden anthropometric tape; Holtain Ltd, Crymych, UK), and the average was used for data analyses. Skinfold thicknesses were measured at the left side of the body to the nearest 0.2 mm using a Holtain skinfold caliper at 2 sites (triceps and subscapular) following standardized procedures (36). Two measurements of each skinfold were performed, and the average value was used for data analyses.

Statistical Analysis

Continuous variables are presented as mean (*SD*), and categorical variables are presented as absolute frequency and percentage. Normality of variables' distribution was tested by Kolmogorov–Smirnov test. One-way analysis of variance or Mann–Whitney *U* test was used for comparisons between groups for normal and non-normal distributed variables, respectively. Differences between categorical variables were tested by chi-square test. Logistic regression models were used to assess odds ratio (OR) and 95% confidence intervals (CIs) for poor sleep quality and short sleep duration according to athletic status and PA level, after adjusting for sex and pubertal status. The analyses were conducted in the total sample as sex interactions were not found between athletic status and sleep data. All the analyses were performed using the IBM SPSS Statistics for Windows (version 22.0; IBM Corp, Armonk, NY). Data are presented as mean (*SD*), median (Mdn), and the interquartile range (IQR) Q1 (25th)–Q3 (75th) or frequency, depending upon the type of data. The level of significance was set to $P < .05$.

Results

Descriptive characteristics of the study population are shown in Table 1. From the total sample, 72% of boys and 54% of girls were classified as an athlete ($P < .01$). Boys were taller and showed higher values of waist circumference, whereas girls presented a higher body fat percentage (all Ps $< .05$). PA data indicated that boys accumulated more daily minutes of moderate, vigorous, and MVPA than girls ($P < .001$). Most of the boys and 7 out of 10 girls achieved daily PA recommendations ($P < .001$). Boys scored lower (better) in PSQI index than girls ($P < .001$). Higher proportions of poor sleep quality (46% vs 26%) were identified among girls ($P < .001$). Sleep duration results were similar between boys and girls ($P > .05$).

Differences according to athletic status are shown in Table 2. Athletes presented a lower body fat percentage compared with nonathletes ($P < .05$). Athletes achieved higher levels of PA at all intensities (all Ps $< .05$) and lower levels of sedentary time ($P < .01$) than nonathletes. Sleep

Table 1 Characteristics of the Study Population by Sex

Variable	All (*N* = 267)	Boys (*n* = 138)	Girls (*n* = 129)	*P* values
Age, y[a]	13.9 (0.3)	13.9 (0.3)	13.9 (0.3)	.92
Tanner stage, I–V[c]	0/21/92/128/26	0/14/45/59/20	0/7/47/69/6	**<.05**
Athletes[c]	170 (64)	100 (72)	70 (54)	**<.01**
Height, cm[a]	163.0 (7.9)	164.7 (8.6)	161.2 (6.7)	**<.001**
Weight, kg[a]	54.0 (9.1)	54.5 (9.6)	53.5 (8.6)	.38
BMI, kg/m^2[a]	20.3 (2.7)	20.0 (2.5)	20.5 (2.8)	.09
Waist, cm[a]	67.2 (5.7)	68.1 (5.5)	66.2 (5.8)	**<.01**
Body fat, %[a]	21.8 (7.2)	18.4 (6.9)	25.4 (5.5)	**<.001**
Sedentary time, min/d[b]	702.5 (662.9–741.1)	709.3 (662.8–747.8)	691.5 (663.1–736.1)	.29
Light PA, min/d[b]	168.5 (154.7–186.7)	166.6 (154.7–183.2)	171.4 (154.3–190.1)	.21
Moderate PA, min/d[b]	74.9 (59.7–87.7)	79.8 (64.2–93.5)	69.4 (56.3–81.5)	**<.001**
Vigorous PA, min/d[b]	10.6 (6.1–17.3)	15.2 (9.2–20.3)	6.8 (3.4–11.3)	**<.001**
MVPA, min/d[b]	85.2 (67.7–105.4)	94.5 (78.6–112.2)	76.4 (63.0–93.1)	**<.001**
MVPA ≥ 60 min/d[c]	231 (86)	129 (93)	102 (79)	**<.001**
PSQI, 0–21[b]	4.0 (3.0–6.0)	4.0 (2.0–6.0)	5.0 (3.5–7.0)	**<.001**
Poor sleep quality[c]	95 (36)	36 (26)	59 (46)	**<.001**
Sleep duration, h[b]	8.0 (7.4–8.6)	7.9 (7.2–8.5)	8.0 (7.6–8.7)	.05
Short sleep duration[c]	134 (50)	73 (53)	61 (47)	.36

Note. Poor sleep quality indicates PSQI > 5. Athletes indicate to play regular sport competitions and ≥3 training sessions per week. Short sleep duration indicates <8 hours per night. Values in bold indicate statistically significant results ($P < .05$).
Abbreviations: BMI, body mass index; MVPA, moderate and vigorous physical activity; PA, physical activity; PSQI, Pittsburgh Sleep Quality Index.
[a]Data are presented as mean (*SD*), and differences between boys and girls were examined by analysis of the variance.
[b]Data are presented as median (25th–75th), and differences between boys and girls were examined by independent-samples Mann–Whitney *U* test.
[c]Data are presented as frequency (%), and differences between boys and girls were examined by independent-samples chi-square test.

quality and sleep duration did not show statistical differences between groups. Additional analyses by sex showed lower PSQI scores (better) in male athletes (Mdn = 4.0, IQR = 2.0–5.0) than female athletes (Mdn = 5.0, IQR = 3.0–7.0; $P < .01$) and in male nonathletes (Mdn = 3.0, IQR = 2.0–6.0) than female nonathletes (Mdn = 5.0, IQR = 3.2–7.0; $P < .01$). Sleep duration did not show statistical differences between male athletes (Mdn = 8.1, IQR = 7.3–8.6 h) and female athletes (Mdn = 7.9, IQR = 7.6–8.7 h; $P > .05$), but male nonathletes (Mdn = 7.6, IQR = 6.9–8.4 h) slept shorter than female nonathletes (Mdn = 8.2, IQR = 7.6–8.9 h; $P < .01$).

Logistic regression models for sleep quality and sleep duration are shown in Table 3. According to athletic status, nonathlete adolescents did not show higher risk for poor sleep quality or short sleep duration (OR = 1.17; 95% CI, 0.68–2.00 and OR = 0.93; 95% CI, 0.56–1.55, respectively). Additional analyses based on PA levels revealed that inactive adolescents did not have higher risk for poor sleep quality or short duration (OR = 1.39; 95% CI, 0.66–2.89 and OR = 1.62; 95% CI, 0.78–3.37, respectively).

Discussion

To our knowledge, this is the first study analyzing differences on sleep quality and sleep duration between athlete and nonathlete adolescents including also objectively measured PA. The main finding of this study was that adolescent athletes did not show poorer sleep quality or shorter sleep duration compared with nonathletes. We also found that adolescent females experience poorer sleep quality than males. Moreover, meeting daily PA recommendations was not related to sleep quality or duration in adolescents.

As regards sex-differences analyses, our results agree with previous studies showing poorer sleep quality in girls (4–6). The underlying reasons of these sex differences remain unclear, and based on our results, only speculative explanations can be given. A recent study analyzing sleep differences by sex (50) proposes that girls are more susceptible to emotional and behavioral problems. In addition, female adolescents experience higher internalization of problems than males (2,5) and may be more concerned about being accepted by peers (17). Biological sex and sex steroids appear to have an important role both in the modulation of sleep and depressive symptoms (1,35). In fact, ovarian steroids fluctuation occurring during different periods of life, such as puberty, has been found to increase sleep complaints (35). Therefore, these gender-specific psychological and physiological factors could make females more susceptible to experience sleep disturbances. In addition, the lower levels of PA observed in girls could also partially explain the sleep differences among sex groups.

Table 2 Body Composition, PA, and Sleep Quality/Duration According to Athletic Status

Variable	Athletes (n = 170)	Nonathletes (n = 97)	P values
BMI, kg/m^{2} [a]	20.2 (2.4)	20.4 (3.1)	.56
Waist, cm[a]	67.3 (5.4)	67.0 (6.3)	.61
Body fat, %[a]	20.8 (6.4)	23.6 (8.1)	**<.01**
Sedentary time, min/d[b]	689.5 (648.3–731.9)	720.3 (684.2–764.1)	**<.001**
Light PA, min/d[b]	171.5 (156.2–189.3)	163.8 (150.4–180.7)	**<.05**
Moderate PA, min/d[b]	79.8 (67.2–92.3)	61.6 (52.2–78.1)	**<.001**
Vigorous PA, min/d[b]	14.8 (9.2–20.4)	5.5 (2.8–9.9)	**<.001**
MVPA, min/d[b]	93.5 (80.2–111.5)	67.7 (58.5–85.0)	**<.001**
PSQI, 0–21[b]	4.0 (3.0–6.0)	5.0 (3.0–7.0)	.42
Poor sleep quality[c]	56 (33)	39 (40)	.23
Sleep duration, h[b]	8.0 (7.4–8.6)	7.9 (7.3–8.6)	.83
Short sleep duration[c]	85 (50)	49 (50)	.93

Note. Poor sleep quality indicates PSQI > 5. Short sleep duration indicates <8 hours per night. Athletes indicate to play regular sport competitions and ≥3 training sessions per week. Values in bold indicate statistically significant results ($P < .05$).

Abbreviations: BMI, body mass index; MVPA, moderate and vigorous physical activity; PA, physical activity; PSQI, Pittsburgh Sleep Quality Index.

[a]Data are presented as mean (*SD*) and differences between athletes and nonathletes were examined by analysis of the variance.

[b]Data are presented as median (25th–75th) and differences between athletes and nonathletes were examined by independent-samples Mann–Whitney *U* test.

[c]Data are presented as frequency (%) and differences between athletes and nonatheletes were examined by independent-samples chi-square test.

Table 3 Logistic Regression Models for Poor Sleep Quality and Duration According to Athletic Status and PA Level

		Sleep quality		Sleep duration	
	***n* (%)**	**OR**	**95% CI**	**OR**	**95% CI**
Athletic status					
athletes	170 (64)	1	Reference	1	Reference
nonathletes	97 (36)	1.17	0.68–2.00	0.93	0.56–1.55
Physical activity					
active	231 (86)	1	Reference	1	Reference
inactive	36 (14)	1.39	0.66–2.89	1.62	0.78–3.37

Note. Analyses were sex- and pubertal status-adjusted. Athletes indicate to play regular sport competitions and ≥3 training sessions per week. Active indicates ≥60 minutes per day MVPA.

Abbreviations: CI, confidence interval; MVPA, moderate and vigorous physical activity; OR, odds ratio; PA, physical activity.

The association between sleep patterns and health status during adolescence is well established (45), but the influence of high-level sport practice on sleep remains to be better elucidated. In agreement with previous research (15,21,37), around 40% of our adolescents showed poor sleep quality, and sleep duration was slightly below the average of European adolescents. However, our data did not show any statistical difference on sleep quality or sleep duration according to athletic status. The logistic regression analyses showed that nonathletes and inactive adolescents did not have higher risk for poor sleep quality or short sleep duration, independently of sex and pubertal status. To our knowledge, this is the first study in performing a predictive analysis to investigate the likelihood of sleep disorders (poor sleep quality and short sleep duration) based on athletic status or PA recommendation achievement.

Previous studies showed that adolescent athletes achieving high levels of PA reported more favorable sleep patterns compared with nonathlete healthy controls (3,4,37). In contrast, more awakenings and less sleep efficiency have been reported in young adult elite athletes (26,41,46). Athletes' training schedule and competitions could increase psychosocial and physiological stress, which has been related with poorer sleep quality in adults (32). Nevertheless, high-intensity exercise has also been related to lower stress and increased mental health in young adults (14,22) and adolescents (4,5). Dealing successfully with the psychological and physiological sport-related demands is highly individualistic and might be influenced by the deep changes occurring during adolescence (8), so its impact on sleep might be different between participants. In our study, a possible effect of the sports participation requirements on sleep patterns may have been minimized by the individual coping strategies adopted by adolescents (30). Therefore, the heterogeneity of the analyzed samples together with the methodological differences among studies could partially explain the controversial results found regarding sports practice and sleep patterns.

Current recommendation of PA for adolescents (at least 60 min/d of MVPA) is associated with a high number of physical and psychological health benefits (49). Nevertheless, based on objective PA assessment carried out in our study, this recommendation is not related with sleep quality or duration in healthy adolescents. Conversely, in a vast group of adults from 18 to 85 years, meeting PA recommendation was associated with a lower risk of feeling sleepy during the day (29). It could be possible that a different amount and/or intensity of PA, higher than 60 minutes per day of MVPA, is needed to affect sleep patterns in adolescents.

The results of this study should be interpreted with caution due to several limitations. First, the direction of causality between PA and sleep patterns cannot be determined due to the cross-sectional design of the study. Second, our nonathlete group was considered on average physically active according to the PA recommendations for adolescents. Due to the voluntary participation in the study, the nonathletes included in this group may be more favorable toward being physically active than other peers. For that reason, they may not be representative of the general adolescent population, as 62.6% of Spanish adolescents do not meet the PA recommendations (33). Therefore, the lack of significant findings could be related to the fact that the nonathletes group was not considered physically inactive. Third, we did not consider other potential confounders in the analyses such as training schedule or caffeine consumption. Despite these limitations, the main strengths of our study include a homogenous sample of adolescents in terms of age and sex with different competitive sport participation and PA levels assessed objectively by accelerometry.

In conclusion, the findings of this study add new information about the relationship between PA and sleep in adolescents, indicating that high-level sport practice did not affect sleep patterns in our sample. In addition, our data suggest that current PA recommendations for adolescents may not discriminate between good and poor sleepers. Parents, coaches, and educators should consider our data to promote regular PA and competitive sports for children and adolescents for general health and sleep as they do not seem to be detrimental for sleep quality and duration. Further longitudinal and interventional studies examining the relationship between PA and sleep are still needed.

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