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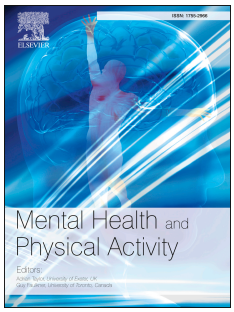

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Lovro Štefan, Tomislav Krističević, Goran Sporiš

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The associations of self-reported physical fitness and physical activity with sleep quality in young adults: a population-based study

Running title: Physical fitness, physical activity and sleep quality

Lovro Štefan, MSc[1], Tomislav Krističević, PhD[2], Goran Sporiš, PhD[3]

[1]Faculty of Kinesiology, Department of General and Applied Kinesiology, University of Zagreb, 10 000 Zagreb, Croatia

[2]Faculty of Kinesiology, Department of Sports Kinesiology, University of Zagreb, 10 000 Zagreb, Croatia, e-mail: tomislav.kristicevic@kif.hr

[3]Faculty of Kinesiology, Department of General and Applied Kinesiology, University of Zagreb, 10 000 Zagreb, Croatia, e-mail: sporis.79@gmail.com

Corresponding author: Lovro Štefan

Faculty of Kinesiology

University of Zagreb, Croatia,

Horvaćanski zavoj 15,

Tel: 0385-09891-77-060

E-mail: lovro.stefan1510@gmail.com

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Abstract

Statement of problem: Although evidence suggests that physical activity and physical fitness are associated with sleep quality, little is known about these associations in young adults. Moreover, existing results have been inconsistent and need further exploration. Thus, the main purpose of the present study was to explore the associations of self-reported physical activity and self-reported physical fitness with sleep quality.

Methods: Two-thousand and one-hundred participants (age; mean±SD=20.87±2.11 years; 50.9% of women) years were recruited. Physical fitness, physical activity and sleep quality were assessed by previously validated questionnaires.

Results: After adjusting for sex, self-rated health, body-mass index, socioeconomic status, smoking status, alcohol consumption, presence or absence of chronic diseases and psychological distress, 'lower' levels of self-reported physical fitness and 'insufficient' self-reported physical activity were associated with poor sleep quality. When entered simultaneously into the model, both 'lower' levels of self-reported physical fitness and 'insufficient' self-reported physical activity remained associated with poor sleep quality.

Conclusion: Our results show that "lower" levels of physical fitness and "insufficient" physical activity are associated with "poor" sleep quality in a large sample of young adults. Thus, special policies and strategies that enhance physical fitness and physical activity as protective factors are warranted.

Key words: exercise; university students; sleeping habits; public health; logistic regression

1. Introduction

Poor sleep quality has become an increasing public health problem, leading to negative health outcomes, such as lower self-rated health (Geiger, Sabanayagam & Shankar, 2012), and higher risk for cardiovascular and metabolic diseases and overall mortality (Sigurdson & Ayas, 2007). Problems related to sleep quality affect approximately 40% of young adults (Centers for Disease and Control Prevention, 2011) In this specific population, poor sleep quality and insufficient sleep lead to increased risk of car crashes (Danner & Phillips, 2008), mental problems (Glozier et al., 2010) and delinquent behaviours (Clinkinbeard et al., 2011).

Although sleeping drugs have been used to improve sleep quality (Richey & Krystal, 2011), the use of such substances often leads to negative side effects (Wawtson, Baghdoyan & Lydic, 2010). Recently, a great attention has been put in promoting physical activity (Gerber, Brand, Holsboer-Trachsler & Puhse, 2010; Lund, Reider, Whiting & Prichard, 2010; Loprinzi & Cardinal, 2011; Kakinami et al., 2017) and physical fitness (Lee & Lin, 2007; Chang & Chen, 2015; Franquelo-Morales et al., 2016), in order to improve sleep quality. The population group of young adults, compared with children and adolescents, generally does not meet the recommendations for physical activity and fitness levels (Cocca, Liukkonen, Mayorga-Vega & Viciana-Ramírez, 2014), which could potentially lead to sleep consequences. However, the associations of physical activity and physical fitness with sleep quality have been inconsistent. While some studies reported positive health benefits of physical activity and physical fitness on sleep quality (Loprinzi & Cardinal, 2011; Lee & Lin, 2007; Brand, Kalak, Gerber, Kirov, Puhse & Holsboer-Trachsler, 2014; Buman, Phillips, Youngstedt, Kline & Hirshkowitz 2014; Chang & Chen, 2015; Franquelo-Morales et al., 2016; Lang, Kalak, Brand, Holsboer-Trachsler, Puhse, & Gerber, 2016), other studies showed no association (Lund, Reider, Whiting & Prichard, 2010; Kakinami et al., 2017).). Such findings could be explained by using a relatively small sample size (Lee & Lin, 2007; Chang & Chen, 2015) and different methodological approach (subjective vs. objective measures) (Gerber, Brand, Holsboer-Trachsler & Puhse, 2010; Loprinzi & Cardinal, 2011; Kakinami et al., 2017). In general, recent meta-analytical review has shown that regular exercise has small beneficial effects on sleep efficiency, small-to-medium beneficial effects on sleep onset latency and moderate beneficial effects on sleep quality (Kredlow, Capozzoli, Hearon, Calkins & Otto, 2015). Similar findings have also been found in studies of Lang et al. (2016) and Chennaoui et al. (2015).

According to aforementioned, there has been mixed results about the association of physical activity and physical fitness with sleep quality, especially in young adults. In general, sleeping problems start to occur in young adulthood (Matthews, Danese, Gregory, Caspi, Moffitt & Arseneault, 2017), because of big lifestyle changes they go through, such as greater independence by leaving home, starting to go to university or beginning to work (Maslowsky & Ozer, 2014; Quick et al., 2016). Also, as mentioned before, insufficient and poor sleep are associated with mental problems (Glozier et al., 2010), vehicle crashes (Danner & Phillips, 2008), and delinquent behaviours (Clinkinbeard et al., 2011). On the other hand, it has been reported that approximately 40% of young adults do not meet the recommendations of National physical activity guidelines (150 min of moderate or 75 min of vigorous physical activity weekly) leading to negative health outcomes, including the increased risk of psychological well-being and poorer sleep quality (Warburton, Nicole & Bredin, 2006).

Thus, the main purpose of the present study was to explore, whether self-reported physical activity and self-reported physical fitness are associated to sleep quality in a large sample of young adults. Based on previous studies, the associations of physical activity and physical fitness with sleep quality are still unclear and need further investigation. Therefore, in this study we hypothesised, that participants who did not meet the recommendations for physical activity and had 'lower' levels of physical fitness would have greater likelihood of reporting 'poor' sleep quality, compared to their 'sufficiently' active peers with 'higher' levels of physical fitness.

2. Methods

2.1. *Participants*

We conducted a study among university students in Zagreb, the capital city of Croatia with approximately 1,000,000 citizens. The University of Zagreb is composed of 33 faculties - departments and between 65,000 and 70,000 attend the University every year. A random sampling with replacement of faculties was conducted. At the first stage, we randomly selected 8 (approximately 8,500 students) out of 33 faculties. The randomization was done with replacement, where each faculty had unique number and was drawn from the box. At the second stage, we contacted teachers from each faculty to help us organize the sampling procedure. A recruitment announcement was sent via emails and e-newsletter to the teachers with a request to

pass the study information to students. All eight faculties agreed to take part in the study. Of these 8,500 students, 2320 (27.3%) were enrolled in the 2017 academic year. At the end, 2100 students (1041 men and 1059 women, aged 18-24 years) provided full complete data (90.5%) and were included in further analysis. Students came from a variety of social (psychology, political sciences, economy and business), technical (computing, information technologies, electrical engineering, civil engineering, mechanical engineering, graphics arts and naval architecture) and health-related (medical doctors, physiotherapists, nurses) sciences. Before the main analysis, we examined the differences between the participants who provided valid data compared with those with incomplete data in terms of sex, age, body-mass index, self-rated health and psychological distress. No significant differences were observed and no potential bias was done (p=0.21-0.74). Before the study began, all participants had provided written informed consent for participation in the study. All the analysis and procedures were anonymous and in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the Faculty of Kinesiology (Ethics code: 16/2017).

2.2. *Measures*

2.2.1. *Sleep quality*

Sleep quality was assessed by Pittsburgh Sleep Quality Questionnaire (PSQI), highly reliable and valid instrument specifically design to measure sleep quality (Buysse, Reynold, Monk, Berman & Kupfer, 1989). It is composed of 19 questions, which create 7 major components. Each component is scored from 0-3 points (0=not during the last month, 1=less than one a week, 2=ones or twice a week and 3=three or more times a week)in following order: (1) subjective sleep quality (very good vs. very bad), (2) sleep latency (≤15 minutes to >60 minutes), (3) sleep duration (≥7 hours to <5 hours), (4) sleep efficiency (≥85% to <65% hours sleep/hours in bed), (5) sleep disturbances (not during the past month to ≥3 times per week), (6) use of sleeping medications (none to ≥3 times a week) and (7) daytime dysfunction (not a problem to a very big problem). All 7 components are then summed up to create a score from 0-21 points. For the purpose of the present study, we dichotomized the result into two categories: (1) ≤5 (good sleep quality) vs. (2) >5 (poor sleep quality), as proposed by Buysse et al. (1989). The reliability of the PSQI was satisfactory (Cronbach's α=0.73).

2.2.2. *Physical fitness*

Self-reported physical fitness was measured with one item ranging from 1 (very poor) to 10 (excellent) (Plante, LeCaptain & McLain, 2000). This measure has previously been correlated with measures of objective physical fitness (Plante, Lantis & Checa, 1998) and used in similar studies (Gerber, Brand, Holsboer-Trachsler & Puhse, 2010). For the purpose of this study, we arbitrary divided the numerical outcome into five categories as follows: very poor (1 and 2), poor (3 and 4), fair (5 and 6), good (7 and 8) and excellent (9 and 10) physical fitness.

2.2.3 *Physical activity*

To assess physical activity in the last 7 days, we used International Physical Activity questionnaire, a reliable and valid instrument designed to measure physical activity in respondents between ages 18-65 (Craig et al., 2003). We created a dichotomized variable, where 'sufficiently active' participants participated in at least (1) 150 min/week in moderate physical activity or (2) 75 min of vigorous physical activity compared with 'insufficiently active' participants (World Health Organization, 2010).

2.2.4. *Covariates*

Smoking status was categorized as: (1) non-smoker, (2) former smoker and (3) present smoker. Participants self-reported their height in meters (m) and weight in kilograms (kg), from which body-mass index (kg/m^2) was calculated. Before the study began, we had chosen 35 men and 40 women to validate self-reported height and weight with the objective measure taken by trained survey staff. Pearson's correlation coefficient showed excellent relationship between two measures in men (r=0.96) and women (r=0.97). For the purpose of this study, we divided body-mass index score into two categories: (1) normal (<25 kg/m^2) vs. (2) overweight/obesity (≥ 25 kg/m^2). Although not appropriate as a clinical tool, self-reported BMI serves as a valid tool for epidemiological surveys, especially in young adults (Meyer, Wall, Larson, Laska & Neumark-Sztainer, 2012). The presence or absence of a chronic disease was assessed using a one-item question:"Have you ever been told by a doctor, that you suffer from any kind of chronic disease?" with "Yes" and "No" answers. Alcohol consumption was assessed by one-item

question:“ How often do you have (for men) 5 or more and (for women) 4 or more drinks on one occasion?“ (Peltzer & Pengpid, 2016). Those who had (for men) 5 or more and (for women) 4 or more drinks on one occasion were categorized as “Yes“ compared to “No“ group, who had less drinks on one occasion. Psychological distress was assessed by using Kessler's 6-item questionnaire: (1) “How often during the past 30 days did you feel nervous?”, (2) “How often during the past 30 days did you feel hopeless?”, (3) “How often during the past 30 days did you feel restless or fidgety?”, (4) “How often during the past 30 days did you feel so depressed that nothing could cheer you up?”, (5) “How often during the past 30 days did you feel that everything was an effort?” and (6) “How often during the past 30 days did you feel worthless?” (Kessler et al., 2003). Each question is scored from 0 (none of the time) to 4 (all of the time). Scores of each question are summed up between 0-24, with lower score indicating lower level of psychological distress. Kessler et al. (2003) showed, that responses <13 points vs. ≥13 points discriminated participants without and with psychological distress. Self-rated health was assessed using one-item question:“How would you rate your health?“. Answers were arranged along a Likert-type scale as follows: (1) very poor, (2) poor, (3) fair, (4) good and (5) excellent. For the purpose of this study, we dichotomized the outcome variable into 'good' (fair, good and excellent) vs. 'poor' (very poor and poor) self-rated health (Štefan, Juranko, Prosoli, Barić & Sporiš, 2017).

2.3. *Data analysis*

Basic descriptive statistics are presented as frequencies (N) and percentages (%). Differences between 'good' vs. 'poor' sleep quality in all variables were analyzed by using Chi-square test. To explore the associations of self-reported physical fitness and physical activity with sleep quality, a set of logistic regression analysis was performed. We calculated odd ratios (ORs) with 95% confidence intervals (95% CIs). After adjusting for sex, self-rated health, body-mass index, socioeconomic status, smoking status, alcohol consumption, presence or absence of chronic diseases and psychological distress, we explored the associations of self-reported physical fitness and sleep quality in model 1 and self-reported physical activity and sleep quality in model 2. Finally, we entered both self-reported physical fitness and physical activity simultaneously into the model 3 to explore the associations with sleep quality. Significance was set up at $\alpha \leq 0.05$ and

it was two sided (2-sided). All the analysis were performed in Statistical Package for Social Sciences Software, ver. 22 (IBM Corp., Armonk, NY, USA).

3. Results

Basic descriptive statistics of the study participants are presented in Table 1. Higher percentage of participants with 'good' sleep quality reported having higher values of self-reported physical fitness and were more physically active compared with 'poor' sleep quality group. Next, higher percentage of women, participants with 'poor' self-rated health and higher body-mass index reported having 'poor' sleep quality. Interestingly, current smokers and participants with the presence of chronic diseases and 'high' psychological distress were also categorized as 'poor' sleepers.

Table 2 shows the associations of self-reported physical fitness and physical activity with sleep quality. After adjusting for sex, self-rated health, body-mass index, socioeconomic status, smoking status, binge drinking, presence or absence of chronic diseases and psychological distress, compared to ‘excellent’ self-reported physical fitness, very poor (OR=2.50; 95% CI 1.54 to 4.07), poor (OR=2.00; 95% CI 1.32 to 3.03) and fair (OR=1.56; 95% CI 1.11 to 2.20) self-reported physical fitness and 'insufficient' self-reported physical activity (vs. self-reported ‘sufficient’ physical activity, OR=1.53; 95% CI 1.23 to 1.91) were associated with poor sleep quality (model 1 and model 2). When self-reported physical fitness and physical activity were entered simultaneously into the model (model 3), very poor (OR=2.27; 95% CI 1.38 to 3.72), poor (OR=1.83; 95% CI 1.20 to 2.80) and fair (OR=1.49; 95% CI 1.05 to 2.11) self-reported physical fitness and 'insufficient' self-reported physical activity (OR=1.31; 95% CI 1.04 to 1.64) were associated with 'poor' sleep quality. The association between self-reported physical fitness and self-reported physical activity was moderate (r=0.33, $p<0.001$). Although self-reported physical fitness and self-reported physical activity were moderately associated, variance inflation factors test (VIF) showed no multicollinearity (1.15 to 1.30).

4. Discussion

The main purpose of the present study was to explore the associations of self-reported physical fitness and self-reported physical activity with sleep quality in a large sample of young adults.

Our findings showed that lower self-reported physical fitness and 'insufficient' self-reported physical activities were associated with 'poor' sleep quality.

Studies have shown beneficial effects of physical fitness and physical activity in promoting falling asleep and 'good' sleep quality (Urponen, Vuori, Hasan & Partinen, 1988). Our results are similar with other studies conducted in young adults (Lee & Lin, 2007; Chang & Chen, 2015; Franquelo-Morales et al., 2016; Lang, Kalak, Brand, Holsboer-Trachsler, Puhse, & Gerber, 2016). Specifically, poor sleep quality was associated with lower levels of muscular endurance, flexibility and cardio-respiratory fitness in the population of young adults (Lee & Lin, 2007; Chang & Chen, 2015). Although the physiological interaction between physical fitness, physical activity and sleep quality remains unclear (Dolezal, Neufeld, Boland, Martin & Cooper, 2017), our findings showed that participants reported having very poor, poor or fair physical fitness and were 'insufficiently active' were more likely to report poor sleep quality.

A few previous studies have tried to explain physiological and psychological effects of physical activity on sleep quality (Chennaoui, Arnal, Sauvet & Léger, 2015; Lang, Kalak, Brand, Holsboer-Trachsler, Puhse, & Gerber, 2016). Specifically, regular physical activity increases body-temperature after which the thermoregulatory mechanism comes into play, steadily decreasing body-temperature through peripheral heat dissipation and vasodilatation, which seems to be essential for improving sleep quality (Raymann, Swaab & Van Someren, 2008). Moreover, sleep loss and ‘poor’ sleep in general induce elevated levels of cortisol and decreased levels of testosterone (Uchida, Shioda, Morita, Kubota, Ganeko & Takeda, 2012), and physical activity could be a protective factor in sleep deprived subjects. Among several physiological mechanisms, physical activity also influences on psychological well-being. In general, it has been well-documented that physical activity improves mood, especially during the night (Dunn, Trivedi, Kampert, Clark & Chambliss, 2005). Also, physical activity is significantly associated with a decrease in mental health problems (especially anxiety or depression) and can improve mental state and decrease rapid eye movement sleep (Cartwright, Baehr, Kirkby, Pandi-Perumal & Kabat, 2003).

In general, regular physical activity reduces the incidence of all-cause mortality and lowers the risk for cardiovascular, metabolic and musculoskeletal diseases (Warburton, Nicol & Bredin, 2006). Most of risk factors for lifestyle disease increase between the ages 18 to 25, pointing out that special interventions and policies that leverage both physical and mental health are

warranted (Burke, Beilin, Dunbar & Kevan, 2004). Moreover, the purpose of most of the strategies is to consume some kind of pharmacological substances that occasionally lead to negative health outcomes (Wawtson, Baghdoyan & Lydic, 2010). As pointed by one recent study, regular physical exercise has moderate beneficial effects on sleep quality, leading to improved sleep and decreased sleep disturbances (Kredlow, Capozzoli, Hearon, Calkins & Otto, 2015). We also observed moderate (r=0.33) correlation between self-reported physical activity and self-reported physical fitness which is in line with other studies (Gerber, Brand, Holsboer-Trachsler & Puhse, 2010). Specifically, Gerber et al. (2010) showed that 24.5% of the participants who did not perceive a lack of physical activity were in the group with the lowest exercise level and 16.1% who perceived themselves as not 'sufficiently' active figured in the group with the highest amount of exercise. Therefore, inaccurate perception of self-reported physical activity and self-reported physical fitness lead to the conclusion that these factors should be observed both separately and simultaneously. Therefore, physical activity/exercise serves as a moderator towards sleeping habits in people, regardless of age (Kredlow, Capozzoli, Hearon, Calkins & Otto, 2015).

Our study has some limitations. First, we used a cross-sectional design, so we cannot exclude the possibility of reverse causality, that is, poor sleep quality led to poor physical fitness and insufficient physical activity. Second, we used subjective measures to assess sleep quality, physical fitness and physical activity. Self-report measures tend to lead to considerable measurement error, recall bias and social desirability effect (Shepard, 2003), and therefore there is a possibility of common method bias which may have resulted in bias away from the null. Moreover, students completed the questionnaires at the individual level, referring to the students' individual perception of sleep quality, physical activity and physical fitness.

5. Conclusion

Our results show strong associations of 'lower' levels of self-reported physical fitness and 'insufficient' self-reported physical activity with 'poor' sleep quality in a large sample of young adults. Findings of this study should be taken into account, when establishing and implementing special strategies and policies that leverage higher participation in physical activity in order to improve sleep quality in a risk group of young adults.

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Table 1. Basic descriptive statistics of the study participants, Croatia (2017)

Study variables	Good sleep quality (N=1310)	Poor sleep quality (N=790)	*p*-value*
	N (%)	N (%)	
Physical fitness			
Excellent (9-10)	149 (11.4)	62 (7.8)	
Good (7-8)	588 (44.9)	249 (31.5)	
Fair (5-6)	411 (31.4)	298 (37.7)	
Poor (3-4)	109 (8.3)	110 (13.9)	
Very poor (1-2)	53 (4.0)	71 (9.0)	**<0.001**
Physical activity			
Sufficiently active	1065 (81.3)	561 (71.0)	
Insufficiently active	245 (18.7)	229 (29.0)	**<0.001**
Sex			
Men	684 (52.2)	357 (45.2)	
Women	626 (47.8)	433 (54.8)	**0.002**
Self-rated health			
Good	1236 (94.4)	699 (88.5)	
Poor	74 (5.6)	91 (11.5)	**<0.001**
Body-mass index			
<25 kg/m^2	1092 (83.4)	614 (77.7)	
≥25 kg/m^2	218 (16.6)	176 (22.3)	**0.002**
Socioeconomic status			
High	193 (14.7)	111 (14.1)	
Medium	1090 (83.2)	654 (82.8)	
Poor	27 (2.1)	25 (3.2)	0.27
Smoking status			
No	948 (72.4)	531 (67.2)	
Former	66 (5.0)	49 (6.2)	
Yes	296 (22.6)	210 (26.6)	**0.04**
Alcohol consumption			
No	961 (73.4)	569 (72.0)	
Yes	349 (26.6)	221 (28.0)	0.51
Chronic diseases			
No	1207 (92.1)	698 (88.4)	
Yes	103 (7.9)	92 (11.6)	**0.005**
Psychological distress			
<13 points	1238 (94.5)	640 (81.0)	
≥ 13 points	72 (5.5)	150 (19.0)	**<0.001**

*Chi-square test

Table 2. The associations between physical fitness, physical activity and poor sleep quality in the study participants, Croatia (2017)

Study variables	Model 1	Model 2	Model 3
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Physical fitness			
Excellent (9-10)	Ref.		Ref.
Good (7-8)	0.99 (0.70 to 1.38)		0.97 (0.69 to 1.36)
Fair (5-6)	1.56 (1.11 to 2.20)*		1.49 (1.05 to 2.11)*
Poor (3-4)	2.00 (1.32 to 3.03)***		1.83 (1.20 to 2.80)**
Very poor (1-2)	2.50 (1.54 to 4.07)***		2.27 (1.38 to 3.72)***
Physical activity			
Sufficiently active		Ref.	Ref.
Insufficiently active		1.53 (1.23 to 1.91)***	1.31 (1.04 to 1.64)*
Sex			
Men	Ref.	Ref.	Ref.
Women	1.08 (0.89 to 1.32)	1.21 (1.00 to 1.40)*	1.06 (0.87 to 1.29)
Self-rated health			
Good	Ref.	Ref.	Ref.
Poor	1.53 (1.08 to 2.17)*	1.43 (1.01 to 2.03)*	1.45 (1.02 to 2.06)*
Body-mass index			
<25 kg/m^2	Ref.	Ref.	Ref.
≥25 kg/m^2	1.37 (1.08 to 1.74)**	1.45 (1.15 to 1.84)**	1.37 (1.08 to 1.75)**
Socioeconomic status			
High	Ref.	Ref.	Ref.
Medium	0.90 (0.69 to 1.18)	0.96 (0.74 to 1.25)	0.90 (0.69 to 1.18)
Poor	0.95 (0.50 to 1.80)	1.10 (0.59 to 2.06)	0.96 (0.51 to 1.81)
Smoking status			
No	Ref.	Ref.	Ref.
Former	1.08 (0.86 to 1.35)	1.12 (0.90 to 1.40)	1.08 (0.87 to 1.35)
Yes	1.24 (0.83 to 1.85)	1.21 (0.81 to 1.81)	1.23 (0.82 to 1.84)
Alcohol consumption			
No	Ref.	Ref.	Ref.
Yes	1.04 (0.84 to 1.29)	1.05 (0.85 to 1.29)	1.04 (0.84 to 1.28)
Chronic diseases			
No	Ref.	Ref.	Ref.
Yes	1.25 (0.91 to 1.72)	1.32 (1.01 to 1.75)*	1.25 (0.91 to 1.71)
Psychological distress			
<13 points	Ref.	Ref.	Ref.
≥ 13 points	3.37 (2.48 to 4.58)***	3.58 (2.64 to 4.85)***	3.36 (2.47 to 4.57)***

Model 1: examine the association of physical fitness with poor sleep quality adjusted for sex, self-rated health, body-mass index, socioeconomic status, smoking status, binge drinking, chronic diseases and psychological distress.
Model 2: examine the association of physical activity with poor sleep quality adjusted for sex, self-rated health, body-mass index, socioeconomic status, smoking status, binge drinking, chronic diseases and psychological distress.
Model 3: examine the associations of physical fitness with physical activity entered simultaneously into the model with poor sleep quality adjusted for sex, self-rated health, socioeconomic status, smoking status, binge drinking, chronic diseases and psychological distress.
***p<0.001, **p<0.01, *p<0.05

Highlights

- Examined the associations of self-reported physical activity and self-reported physical fitness with sleep quality in a large sample of young adults (*N*=2100).
- ’Insufficient’ self-reported physical activity ‘lower’ levels of self-reported physical fitness was associated with ‘poor’ sleep quality.
- ‘Lower’ levels of self-reported physical fitness were associated with ‘poor’ sleep quality.