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SHORT REPORTS

The Correlation between Night Sleep Duration and Physical Activity with Cardiorespiratory Fitness Test Results in Healthy Medical College Students: a Pilot Study

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Abstract

Lack of sleep is the risk factor for a cardiovascular event and low cardiorespiratory endurance. Medical college students are more frequent in experiencing a lack of sleep due to their duty. This study evaluated the correlation between lack of sleep and cardiorespiratory endurance test results in medical college students. This cross-sectional study involved sixty-two males, medical college students. Sleep duration of two weeks was assessed using a validated questionnaire. Queen College Step test was employed for a cardiorespiratory endurance test. Spearman rank test was employed to evaluate the correlation between variables, while logistic regression was applied to assess the possibility of having a good VO_{2max}. SPSS version 19 was used to process the data and perform a statistical test. Significance was set at $p<0.05$. The mean sleep duration was 6.2 hours, with more students having insufficient sleep duration (51 participants). The mean VO_{2max} was 50.4 ml/kg/min, with more students having good VO_{2max} (50 participants). Spearman rank test indicated the weak correlation between age and sleep ($r=0.2$, $p=0.04$) and a moderate correlation between physical activity and VO_{2max} ($r=0.43$, $p<0.01$). No correlation between sleep and VO_{2max} result ($p=0.07$). Logistic regression showed sufficient physical activity is associated with 14.5 times possibility of having good VO_{2max} (95% CI 2.7-77.8, $p=0.02$). The correlation between sleep and the VO_{2max} result was not evident. Instead, sleep was associated with students' age while VO_{2max} with sufficient physical activity.

Keywords: *Cardiorespiratory Fitness, Sleep Deprivation, College Students, Risk of Heart Diseases*

Introduction

Sleep is essential for the proper function of the organ system, including the musculoskeletal (Mental Health Foundation, 2018). Usually, a night sleep duration is 7-9 hours. Sleep duration of fewer than 7 hours is generally considered lacking. Lack of sleep duration is associated with health problems such as obesity, diabetes, hypertension, heart disease and stroke, depression, and even an increased risk of death. A cohort study conducted with a large sample observed that people who have disorders or lack of sleep would have risk factors for heart disease (Garde, Hansen, Holtermann, Gyntelberg, & Suadicani, 2013). Sleep deprivation is associated with a 48% increased risk of coronary heart disease and a 15% increased risk of stroke (Holst, Sousek, & Landolt, 2014). In comparison, sleep duration of more than 9 hours at night is assumed as long sleep. Sleep deprivation is also associated with some disturbances such as mild depression, anxiety, social withdrawal, and death (Patel, Malhotra, Gottlieb, White, & Hu, 2006; Watson, et al., 2015).

There is a high level of stress in medical students due to high academic demands. They spent a lot of their time studying and internship in a hospital with night duty. This causes them to have short-

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er sleep duration and lower participation in exercise. Many students complain of a lack of sleep, sleepiness, sleep deprivation, and learning difficulties during college (Giri, Baviskar, & Phalke, 2013). Sleep deprivation elicits physiological responses such as increased sympathetic activity leading to vasoconstriction, bronchodilation, and increased heart rate, and decreased insulin secretion (Castro-Diehl et al., 2016). If this response occurs chronically, it will disturb many organ functions.

Cardiorespiratory endurance is one of the health-related physical fitness components besides muscle strength & endurance, flexibility, and body composition (Russell, Oria, & Pillsbury, 2012). Cardiorespiratory endurance refers to the capability of the heart and lungs to deliver oxygen to the muscle during activity. Thus, it is a suitable parameter to assess heart and lung function. Cardiovascular risk is associated with low cardiorespiratory endurance (Rodrigues, Perez, Carletti, Bissoli, & Abreu, 2007). Maximum oxygen uptake (VO_{2max}) can measure cardiorespiratory endurance during exercise tests. The VO_{2max} can be yielded using standard methods, either maximal or submaximal tests (American College of Sports Medicine, 2006). The tests could be conducted simply by walking, jogging, running, or bench stepping. The submaximal test is considered a saver for patients, disabled, and unfit people (Gappmaier, 2012; Noonan & Dean, 2000).

Sleep quality and duration can reduce the level of physical activity and disturb the cardiorespiratory endurance test. Antunes et al. investigated the effect of sleep quality and duration on maximal incremental test performance in healthy. They observed that participants with good sleep quality had higher power and cardiorespiratory endurance test and a low maximal heart rate (Antunes et al., 2017). Also, a review article by Kline stated that exercise and sleep have a bidirectional relationship. Exercise could improve sleep disturbance, whereas poor sleep quality lowers physical activity (Kline, 2014). Therefore, this study investigates the correlation between sleep duration, physical activity and endurance tests in medical college students, to determine whether sleep duration and physical activity could influence submaximal endurance test results.

Methods

Participants

The design of this study was a cross-sectional with descriptive-analytic. Sixty-two students participated in the study. Inclusion criteria were set as follows: male students, healthy. Exclusion criteria included taking medication causing drowsiness or sleep, sleep disturbance due to any caution (anxiety, depression, etc.), mobility impairment, physical weakness due to several causes, musculoskeletal disorders affecting lower limbs or respiratory muscles. Participants agreed to participate and gave their informed consent after an explanation. This study was conducted from May to August 2019. The ethics commission of the School of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia, had approved the study (No: 22/12/KEP-FKUAJ/2019).

Data Retrieval

A questionnaire was employed for primary data, inclusion and exclusion criteria, and sleep behavior. The questionnaire recorded the sleep behavior of participants for two weeks. The questions had been validated. Sleep duration was mean sleep duration for 14 days, obtained from (ten workdays sleep+four weekend sleep)/14. The sleep duration less than 7 hours denoted insufficient while >7 hours denoted normal. Physical activity (PA) is considered 'insufficient' if doing an exercise or sport less than 30 minutes/session three times a week, while 'sufficient' is 30 minutes or more and three times a week.

Measurements

Weight was measured in minimal clothes using a digital scale (Robusta 813, Seca, Germany), expressed in kg. Height was measured in Frankfort position barefoot using a stadiometer, expressed in cm. Body Mass Index (BMI) was obtained from the weight (kg) divided by the square of height (m), presented as kg/m2. Body mass index was normal if BMI <23 kg/m2, and overweight if BMI ≥23 kg/m2 (Hsu, Araneta, Kanaya, Chiang, & Fujimoto, 2015; WHO Expert Consultation, 2004).

Endurance test

Cardiorespiratory endurance (VO_{2max}) was evaluated using the Queen College Step (QCS) test (QCS). This test was conducted by stepping up and down on a bench with a height of 41.3 cm. The bench height was suitable for Asian people. The pace of stepping followed a metronome rhythm, 24 steps for males and 22 steps per minute for females. The participants completed the test for three minutes. The test was considered to fail if the participants finished the test for less than three minutes. Heart rate at the 15th-second pots test was recorded. The VO_{2max} was calculated from heart rate at 15th second post-test us-

Tables 1. Characteristics of the participants

Variables	Mean±SD or frequency (%)
Age (years)	19.5±0.8
Weight (kg)	70.10±11.9
Height (cm)	170.2±5.5
BMI (kg/m^2)	24.2±3.9
Normal/underweight	23 (37.1%)
Overweight/obesity	39 (62.9%)
Sleep duration (hours)	6.2±0.8
Insufficient	51 (82.3%)
Normal	11 (17.7%)
VO_{2max} (ml/kg/min)	50.4±6.1
Low	12 (19.4%)
Good	50 (80.6%)
Physical activity	
Insufficient	37 (59.7%)
Sufficient	25 (40.3%)

Note. BMI - Body mass index; VO2 max - Maximal oxygen volume

ing equations (for male: VO_{2max} (ml/kg/min) = 111.33 - (0.42 x heart rate (bpm), for female: VO_{2max}(ml/kg/min) = 65.81 - (0.1847 x heart rate) (MacKenzie, 2001). The post-test heart rate was monitored using a heart rate monitor from the smartwatch (Mi Band 3, Xiaomi, China). The test was considered valid to predict maximum oxygen uptake (Chatterjee, Chatterjee, Mukherjee, & Bandyopadhyay, 2004). Participants wore sports clothes during the QCS test. The test was conducted in the morning before the class to ensure the students were still fresh.

Statistical analysis

The numerical data were presented as mean values with standard deviation while categorical data as frequency and percentage. The correlation between VO_{2max} and relating factors was evaluated using the Spearman rank test, while the logistic regression was applied to estimate the possibility of several influencing factors toward VO_{2max}. The significance level was determined at $p<0.05$. The statistical analysis was analyzed using SPSS 19 program.

Results

The characteristics of the participants are presented in Table 1. The mean BMI of the participants exceeded the normal BMI. There were more students with overweight or obesity than normal/underweight (62.9% vs. 37.1%). The mean sleep duration indicates less than normal (< 7 hours). This was confirmed in which there were many more students with a lack of sleep (82.3% vs. 17.7%). Most students had insufficient physical activity (59.7%).

Table 2 describes the correlation between variables by Spearman rank. Most correlations were not significant. Age and sleep had weak positive correlation (r=0.26, p=0.04). Physical activity had a moderate positive correlation with VO_{2max} (r=0.43, p<0.01). The correlation between sleep duration and VO_{2max} was not significant (r=0.23, p=0.07)

Table 2. The correlation by Spearman rank test

	Age	BMI	PA	Sleep	VO_{2max}
Age	1.000	-.161	.023	.260	.122
		.213	.882	.040*	.374
BMI	-	-	-.051	.173	.124
			.702	.191	.346
Physical activity	-	-	-	-.053	.433
				.715	<.011*
Sleep duration	-	-	-	-	.230
					.070

Note. * - indicates p is significant; italic number denotes p score; regular number denotes correlation coefficient (r). BMI - body mass index; PA - physical activity

The logistic regression of variables for 'good' VO_{2max} is presented in Table 3. The only physical activity was significant for VO_{2max}. Participants with 'sufficient' physical activity had a 14.5 times probability of having good VO_{2max} compared to 'insufficient' PA (95%CI 2.7-77.8, p=0.02)

Table 3. Logistic regression for VO_{2max}

Variables		Adjusted OR (95% CI)	p
Age	<20 years (reference)	0.27 (0.03-2.63)	0.26
	≥20 years		
BMI	Normo/underweight (reference)	1.90 (0.29-12.50)	0.51
	overweight/obesity		
Physical activity	Sufficient (reference)	14.5 (2.7-77.8)	0.02
	Insufficient		
Sleep duration	Normal (reference)	6E+008	0.99
	Insufficient		

Note. BMI - body mass index; OR - Odds ratio

Discussion

A study on the correlation between sleep duration and cardiorespiratory endurance test has not been much performed yet. This might be a part of a few studies on the association between sleep duration and cardiorespiratory endurance tests involving medical college students. Our findings indicated that sleep duration did not affect VO_{2max} in medical college students with a mean age of 19.5 years. Participants of this study were more overweight/obese with insufficient sleep duration and physical activity but having good cardiorespiratory endurance tests. Our finding demonstrated that only physical activity was related to VO_{2max}.

Our study observed no significant correlation between sleep duration and VO_{2max} results. Prior studies did not support this finding. A cohort study by Zou et al. investigated the association between insomnia and cardiorespiratory fitness (CRF) in middle-aged people. The results showed a modest association between insomnia and CRF (Zou et al., 2019). At the same time, another study by Countryman et al. observed that sleep quality was associated with CRF in adolescents (Countryman et al., 2013). We had no obvious explanation, but it might be related to age. Young people may have better cardiorespiratory function than middle-aged and adolescents leading to more stable function while facing stress tests.

A study that identifies factors associated with CRF has been performed. Kind et al. made a regression model to estimate VO-

$_{2max}$ in healthy adult workers (Kind et al., 2019). They observed gender, age, waist circumference, smoking habit, and resting heart rate were the most significant factors related to VO_{2max} while BMI did not (Kind et al., 2019). Magutah investigated CRF in college students in Kenya. They observed that year of study, age, weight, and respiratory rate were determinant factors for VO_{2max} results (Magutah, 2013). Aires et al. concluded that increased physical activity and reduced sedentary activities could achieve optimum CRF (Aires et al., 2011). Our findings demonstrated that only physical activity (PA) correlated with VO_{2max} but not with age, BMI, and sleep duration, even age and BMI of our study were relatively homogenous. We assumed that participants with better functional fitness might be more energetic and did not get tired easily, so they did not much sleep. Therefore, sleep duration had less impact on their performance during submaximal stress test (Kredlow, Capozzoli, Hearon, Calkins, & Otto, 2015).

The correlation between exercise and good sleep has been established. In adolescents, a study by Brand et al. reported that athletes had a night of better sleep and psychological functioning than controls (Brand et al., 2010). Banno et al. also stated in a systematic review that exercise could improve sleep quality (Banno et al., 2018). Also, Kline suggested that exercise and sleep had a bidirectional relationship (Kline, 2014). Our findings did not find any correlation between physical activity and sleep duration. This difference finding might be due to intensity of physical exercise. The previous study participants were athletes who trained with high exercise intensity than participants in our study.

Less sleep duration is common among medical students. Huen et al found that about 70% of medical students in Hong Kong reported sleep deprivation (Huen, Chan, Yu, & Wing, 2007), while our study demonstrated 82.3%. A study by Yadav et al. reported that low physical activity and CRF were found among medical students, especially in females (Yadav, Shete, Khan, 2015). Our findings showed that students had 'insufficient 'PA were slightly higher than those with 'sufficient' PA (59.7 vs 40.3%) but most students had a 'good' VO_{2max} (80.6%). These findings indicated that sleep was not an essential requirement for students with good VO_{2max} to achieve a better endurance test result.

We identified some limitations of the study. First, the sample size might be too small, which will significantly affect the statistical results. Second, we included sleep duration only rather than sleep quality. Long sleep duration does not mean good sleep quality. Third, a cross-sectional study less explains the causal-relationship effect. Fourth, the QCS test is a submaximal test that its ability to differentiate CRF between fit and less fit people is less accurate than a maximal test.

Conclusion

This study revealed that lower sleep duration in medical college students is common. However, inadequate sleep duration did not influence the results of the QCS test. Instead, the physical activity was a predictive factor for VO_{2max} from QCST, with OR was 14.5. We should interpret these results with caution due to some limitations. We recommend investigating with larger sample size and including sleep quality using a maximal test for CRF evaluation. The average night sleep duration of 6.2 hours may not affect the results of QCST in medical college students. The results could imply that a sleep duration of about 6 hours might be sufficient for young people to perform daily activities with sufficient quality.

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Conflict of Interest

The authors declare that there is no conflicts of interest.

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