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Effect of Sleep on Cardiorespiratory Fitness of Apparently Healthy Young Adults

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ABSTRACT

Background: Sleep dysfunction affects overall health of a person. Exact effect of sleep on cardiorespiratory fitness is less researched area. This study aimed to explore the effect of sleep on cardiorespiratory fitness by examining the difference in VO_2 max between normal and poor sleep categories and examine the correlation between PSQI score with VO_2 max of apparently healthy young adults.

Methods: A cross-sectional analytical study was conducted in Clinical Physiology Department, Maharajgunj Medical Campus from March 2023 to September 2024. Participants were categorised into normal and poor sleep groups on the basis of PSQI scores. Participants from both groups performed Queen's College step test. Heart rate was monitored post exercise to calculate VO_2 max. Independent samples t-test was used to compare the VO_2 max between the groups. Pearson's correlation test was used to examine correlation of PSQI score with VO_2 max.

Results: A total of 64 participants were enrolled in the study, out of which 45 were males and 19 were females. Mean PSQI score in male participants was 5.53 $\pm$ 2.76 and in female participants was 5.52 $\pm$ 3.44. The mean VO_2 max in normal sleep category was 42.50 $\pm$ 8.61 mL/kg/min and mean VO_2 max in poor sleep category was 41.89 $\pm$ 7.97 mL/kg/min. There was no significant difference in VO_2 max between the two groups (p=0.77). Also, no correlation was found between PSQI score and VO_2 max (r=-0.029, p=0.591).

Conclusions: Impact of sleep quality on cardiorespiratory fitness assessed by VO_2 max could not be established in apparently healthy young adults.

Keywords: Cardiorespiratory fitness; Nepal; Queen's College step test; sleep; VO_2 max.

INTRODUCTION

Cardiovascular diseases are known to be associated with poor sleep quality.[1-3] The relation between sleep quality and cardiorespiratory fitness (CRF) has been inconclusive. Cardiorespiratory fitness as the marker of cardiovascular health can be assessed by maximum oxygen consumption / maximum aerobic capacity (VO_2 max).[4] Queens College step test is a widely accepted test to measure VO_2 max.[5]

Pittsburgh Sleep Quality Index (PSQI) is a widely used self-report questionnaire to assess sleep quality that consists of 19 items measuring seven components of sleep. Each component is scored from 0 to 3 giving a total score of 21. PSQI score of more than 5 indicates poor sleep.[6] This study aimed to examine if VO_2 max differs between normal and poor sleep categories and examine the correlation between PSQI score with VO_2 max to explore the impact of sleep on cardiorespiratory fitness in healthy young medical students.

METHODS

This cross-sectional, analytical study was conducted in Clinical Physiology Department of Maharajgunj Medical Campus from March 2023 to September 2024. Ethical approval was obtained from Institutional Review Committee of Institute of Medicine, Kathmandu with the Ref no: 498 (6-11) E2. All first and second-year undergraduate students of Maharajgunj Medical Campus were contacted by email or phone and informed consent was obtained from the interested participants.

All interested participants were sent sleep questionnaire for completion. A total of 106 participants in the age group of 18 to 24 completed the sleep questionnaire and submitted online. Sleep questionnaire responses were

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examined and PSQI global score was calculated for each participant. On the basis of PSQI score, participants were divided into normal sleep and poor sleep categories. There were 48 participants in normal sleep category and 58 participants in poor sleep category. Random sampling procedure with the use of computer-generated random number was used to select participants for step test and 32 participants from each category were invited for Queens College step test. Participants with cardiac or respiratory disease, bone and joint problems, history of dizziness, unconsciousness, chest pain, asthma, pregnancy and any factor that limits the ability to exercise were excluded from the study. Participants were asked to refrain from eating, drinking caffeinated drink or smoking at least three hours prior to the test.

Participants were asked to complete Physical Activity Readiness Questionnaire (PARQ) prior to the start of Queens College step test to check the fitness for performing exercise. PARQ is a validated screening tool that assess the individual's readiness for exercise.[7] All participants following screening with PARQ underwent resting pulse and blood pressure examination. Blood pressure was recorded manually using the mercury manometer and resting pulse was examined manually for one minute at sitting position.

All participants enrolled for the study underwent anthropometric measurements and a demonstration session of Queens College step test with a member of the research team. Queens College step test is a widely used tool that allows participants to experience moderate form of exercise when performed in the standard manner for 3 minutes at a recommended pace.[5] Each step has four beats: up-up-down-down. Participant's understanding of the procedure and correctness of the step test was assessed by a team member for all participants before the actual step test. After a rest of five minutes, male participants performed the step test with the metronome set at standard rate of 96 beats/min or 24 steps per minute while the female participants performed the step test with the metronome set at standard rate of 88 beats/min or 22 steps per minute for three minutes respectively. Immediately after the stoppage of test, participant remains seated and the pulse was recorded manually within five seconds and measured for 15 seconds to get the 15 seconds pulse rate.

Maximum heart rate (HR max) was calculated by multiplying 15 seconds pulse rate by four. Then pulse rate was also recorded at one minute after the exercise manually to obtain heart rate recovery (HRR). VO_2 max was calculated for all participants using the formula 111.33 - (0.42 x HR max) for males and 65.81 – (0.1847 x HR max) for females.[8] Heart rate recovery (HRR) at one minute was calculated by subtracting the maximum heart rate during exercise with the heart rate at 1 minute post exercise. Normal heart rate recovery at one minute for this study was considered to be 12 bpm and above. VO_2 max was considered normal if it was above 42.5 millilitres/kg/min for male and above 33 millilitres/kg/min for females. [9,10,11]

Data was transferred into Excel 2016. SPSS software version 16 was used for statistical analysis. Descriptive statistical analysis was performed using mean with standard deviation (SD) for the quantitative variables. Independent samples t-test was used to compare means between the two groups. Pearson's correlation test was done to check the correlation between PSQI score and VO_2 max.

RESULTS

Table 1. General characteristics of participants.

Parameters	Male (Mean ± SD)	Female (Mean ± SD)	Total (Mean ± SD)	P Value
Age (Years)	20.29 ± 1.53	19.84 ± 1.17	20.15 ± 1.44	0.26
Height (Cm)	172.98 ± 5.03	159.79 ± 7.25	169.06 ± 8.34	<0.001
Weight (Kg)	63.51 ± 7.47	53.00 ± 10.07	60.39 ± 9.56	<0.001
BMI (Kg/m^2)	21.24 ± 2.46	20.63 ± 2.82	21.06 ± 2.56	0.387
Resting HR (bpm)	78.62 ± 9.52	82.21 ± 7.27	79.68 ± 9.00	0.147
SBP (mmHg)	109.60 ± 11.39	101.79 ± 9.38	107.28 ± 11.35	0.011
DBP (mmHg)	70.77 ± 8.27	69.79 ± 7.05	70.48 ± 7.89	0.651
PSQI Score	5.53 ± 2.76	5.52 ± 3.44	5.53 ± 2.95	0.993
VO_2 max	45.14 ± 7.45	35.23 ± 5.38	42.19 ± 8.23	<0.001

A total of 64 participants enrolled in the study out of which 45 were males and 19 were females. The mean age of the participants was 20.15 ± 1.44 ranging from 18 years to 24 years. The average BMI of the participants was 21.06 ± 2.56 indicating that majority of participants fell under normal BMI category. The average BMI, resting HR, systolic blood pressure and diastolic blood pressure were comparable between both male and female participants. Mean PSQI score in male participants was 5.53 ± 2.76 and in female participants was 5.52 ± 3.44. (table 1)

Table 2. Physiological characteristics of participants as per sleep category.

Parameters	Normal Sleep (Mean ± SD)	Poor Sleep (Mean ± SD)	P Value
Age (Years)	20.15 ± 1.67	20.15 ± 1.19	1.000
Height (Cm)	168.68 ± 8.78	169.44 ± 7.99	0.722
Weight (Kg)	60.15 ± 9.33	60.62 ± 9.92	0.845
BMI (Kg/m^2)	21.06 ± 2.40	21.05 ± 2.75	0.983
Resting HR (bpm)	79.84 ± 9.69	79.53 ± 8.4	0.891
SBP (mmHg)	108.31 ± 12.36	106.25 ± 10.33	0.472
DBP (mmHg)	70.81 ± 7.70	70.15 ± 8.17	0.742

Anthropometric measurements and resting vitals of the participants in both normal and poor sleep category is comparable with no significant difference between the groups. (table 2)

Table 3. PSQI, VO_2 max and HRR at 1 minute as per sleep category.

Parameters	Normal Sleep	Poor Sleep	P Value
PSQI score	3.26 ± 1.26	8.13 ± 2.27	<0.0001
VO_2 max	42.50 ± 8.61	41.89 ± 7.97	0.772
Heart rate recovery at 1 minute (HRR)	53.09 ± 17.46	51.90 ± 19.83	0.800

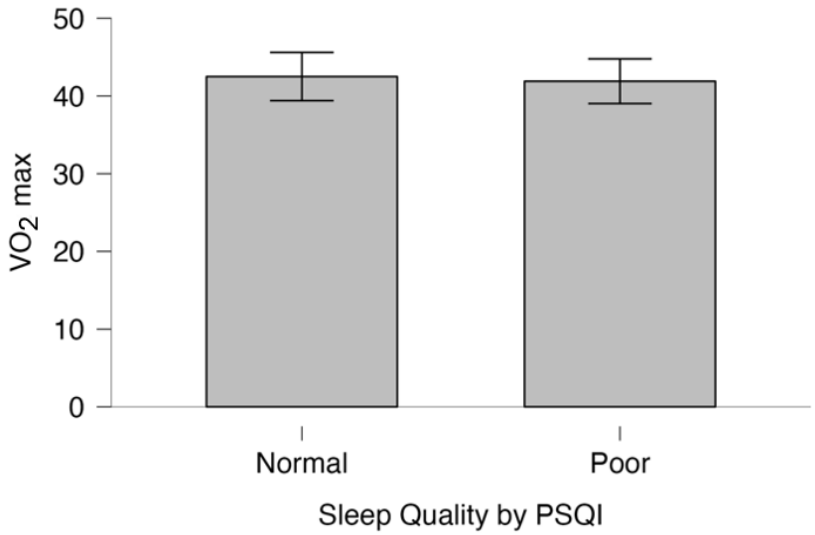

Figure 1. Comparison of VO_2 max between normal sleep and poor sleep category.

No significant difference in VO_2 max and HRR at 1 minute between normal and poor sleep category. (table 3), (figure 1)

Table 4. Pearson correlation between the VO_2 max and PSQI score.

Parameters	PSQI score	P Value
VO_2 max	Pearson's r = - 0.029	0.591

No significant correlation was found between PSQI score and VO_2 max. (table 4)

DISCUSSION

The main finding of this study is that cardiorespiratory fitness was similar in apparently healthy young adults with normal and poor sleep quality. Participants in both normal and poor sleep category had comparable VO_2 max. Also, there was absence of significant correlation between PSQI score and VO_2 max. These findings indicate that sleep quality as measured by PSQI score is not a factor affecting VO_2 max of the study group.

Similar findings were reported by Anderson et al. in 2022 and Mutiara et al. in 2024.[12,13] Mutiara et al. assessed sleep quality using the PSQI questionnaire in 106 adolescent athletes. No significant correlation was reported between subjective sleep quality and VO_2 max estimated using the multi stage fitness test.[13] Similarly, Anderson et al. examined sleep duration rather than sleep quality and also reported no significant association between sleep duration and VO_2 max. These consistent findings may indicate that normal variations in sleep characteristics among young adults are insufficient to produce measurable changes in CRF.[12]

In contrast, Lim et al and Ramania et al. reported a significant association between sleep quality and VO_2 max. This discrepancy in the findings may be explained by differences in participant characteristics, consideration of sleep quality versus sleep duration, study design with different methods used to assess sleep quality and VO_2 max.[14,15] Participants in our study were young adults of both genders while only male adolescents were included in the study by Lim et al.[14] There was also a discrepancy in VO_2 max testing protocols between our study and the above studies.

The additional finding in this study is that males had significantly higher VO_2 max in comparison to females indicating higher CRF in males than females. This finding is consistent with another study conducted among Nepalese students by Prajapati et al.[15] This finding of higher VO_2 max in males could be attributed to greater muscle mass and cardiac output.

This study has some limitations. First, the cross-sectional design prevents causal inference between sleep quality and VO_2 max. Second, sleep quality was assessed using the self-reported PSQI, which is subject to recall and reporting bias. Third, participants were recruited from a single institution with a relatively small sample size, limiting generalizability of the findings. Finally, potential confounding variables such as habitual physical activity, dietary habits, caffeine intake, stress levels, and body composition were not controlled in our study. However, this study builds the foundation upon which future studies on sleep and cardiorespiratory fitness can be performed. We recommend future longitudinal study that analyzes both qualitative and quantitative aspects of sleep and their relationship with cardiorespiratory fitness to derive concrete evidence on the effect of sleep on cardiorespiratory fitness and formulate the appropriate recommendations for populations at risk of sleep disturbances.

CONCLUSIONS

The effect of subjective sleep quality on cardiorespiratory fitness could not be established from the study. There was no difference in cardiorespiratory fitness between young healthy adults with normal and poor sleep quality. No significant correlation was seen between PSQI score and VO_2 max.

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CONFLICT OF INTEREST

Authors declare that there are not any conflicts of Interest.

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