Relationship Between Volume of Physical Activity and Sleep Quality Among College Students

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Abstract

Physical activity (PA) and sleep quality (SQ) are crucial components of a healthy lifestyle. College students have a high prevalence of poor SQ. PA may be an important way to improve SQ. The main purpose of this study was to determine the relationship between volume of physical activity and sleep quality among college students. Participants (n=159) were college students who enrolled at a regional university. Recruitment was done by email blast with online survey link. The International Physical Activity Questionnaire (IPAQ) and Pittsburgh Sleep Quality Index (PSQI) were used to analyze PA and SQ. Total PA, vigorous PA, moderate PA, and light PA were calculated from the IPAQ in MET·min·wk^{-1}. PSQI includes a global sleep quality index with seven component scores. Pearson correlation was used to analyze the relationship between volume of PA and SQ. Independent-t tests and one-way ANOVAs were used to compare differences in SQ in groups created based on volume of reported PA. No significant relationships were observed between any PA variable and SQ. The independent t-test comparing those reporting no vigorous PA and those reporting any vigorous PA showed significantly better SQ in those reporting any vigorous PA (t =-2.14, p=.03). When looking at SQ differences between groups formed based on reported volume of vigorous PA, a significant difference was found (F = 4.79, p=.01). Those reporting a low volume of vigorous PA had significantly better SQ than those reporting no vigorous PA (p = .01) and a trend toward better SQ when compared to those reporting a high volume of vigorous PA (p = .08). The conclusion of this study was that college students who reported small amounts of vigorous activity reported better SQ as compared to vigorously inactive college students. This study could help to understand the importance of PA to improve sleep quality among college students.

Chapter One: Introduction

College students are unique individuals who are confronted with many challenges and social developmental transitions. This population has a high prevalence of poor sleep quality (SQ) and it has been linked to poor menta l health, life satisfaction, and academic performance (Feng et al., 2014). As a result, improving sleep quality and preventing mental problems could have a large impact on this group (Feng et al., 2014). Despite the fact that good sleep is vital for health and that adults spend more than 30% of their life sleeping, the majority of university students do not get the required amount of sleep each night and the number of hours of sleep in this demographic has decreased over the years. Between 1969 and 2001, the average number of hours of sleep for postsecondary students fell from eight to fewer than seven per night, indicating an increase in self-reported sleep quality dissatisfaction (Badicu, 2018).

In terms of primary prevention and therapeutic education, physical activity (PA) and sleep are crucial components of a healthy lifestyle. Every movement performed by the skeletal muscles that moves the body and results in a significant increase in energy consumption is classified as PA. A rest period, on the other hand, is defined by a lack of activity or daily repose (Badicu, 2018). The minimal degree of physical activity required to achieve health benefits for adults aged 18–65 years is 150 minutes of moderate or 75 minutes of vigorous physical activity per week in addition to two days of strengthening exercise, according to the Physical Activity Guidelines for Americans (Piercy et al., 2018). Unfortunately, physical inactivity affects 21% of adults aged 15 and over, with a higher prevalence among women and in developed countries (Stefan et al., 2018). The PA levels of college students are notably low. In the United States, about half of college students do not meet PA recommendations (Choi et al., 2018).

Purpose and Hypothesis

The main purpose of this study was to determine the relationship between volume of physical activity and sleep quality among college students. The volume of PA at three different intensities (vigorous, moderate, and light) were measured.

H_0: There is no relationship between volume of physical activity and sleep quality among college students.

H_1: There is a relationship between volume of physical activity and sleep quality among college students.

Operational Definitions

The operational definitions of terms used in this study are explained below:

Physical Activity (PA)

Every movement performed by the skeletal muscles that moves the body and results in a significant increase in energy consumption is classified as PA (Liguori et al., 2021).

Light Physical Activity (Light PA)

According to Liguori et al (2021), light (or low)-intensity physical activity is any non-sedentary waking behavior requiring less than 3.0 METs. The International Physical Activity Questionnaire (IPAQ) calculates the volume of light PA as the product of intensity, frequency, and time of reported weekly light PA using 3.3 METs to estimate intensity (Ekelund et al., 2006; Tomioka et al., 2011).

Moderate Physical Activity (Moderate PA)

Moderate-intensity physical activity is any activity requiring 3.0 to fewer than 6.0 METs (Liguori et al., 2021). The International Physical Activity Questionnaire (IPAQ) calculates the

volume of moderate PA as the product of intensity, frequency, and time of reported weekly moderate PA using 4.0 METs to estimate intensity (Ekelund et al., 2006; Tomioka et al., 2011).

Vigorous Physical Activity (Vigorous PA)

Vigorous-intensity physical activity is any activity which requires 6.0 or more METs (Liguori et al., 2021). The International Physical Activity Questionnaire (IPAQ) calculates the volume of vigorous PA as the product of intensity, frequency, and time of reported weekly vigorous PA using 8.0 METs to estimate intensity (Ekelund et al., 2006; Tomioka et al., 2011).

Sleep

The resting state in which the body is not active and the mind is unconscious (Cambridge University Press, 2022).

Sleep Quality (SQ)

Sleep quality is defined as a person's level of satisfaction with each component of their sleep experience—sleep efficiency, sleep latency, sleep duration, and wakefulness following sleep onset (National Sleep Foundation, 2022)

Limitations

The first limitation of the study was the type of research. This was a survey study which is not as reliable as experimental studies because it relies on self-reported data. Secondly, there are chances of survey errors in which participants may respond with incorrect answers to questions intentionally or unintentionally.

Delimitations

All the participants were enrolled college students.

Assumptions

It was assumed that all the participants will accurately report their physical activity levels and sleep quality.

Conclusion

Physical activity improves sleep quality among college students; however, few studies have focused on what intensity of physical activity will have a greater relationship with sleep quality. Additional research will help to find out the relationship between sleep quality and volume of physical activity at different intensities.

Chapter Two: Literature Review

Introduction

Poor mental health, life satisfaction, and academic achievement have all been related to sleep deprivation among college students. As a result, enhancing sleep quality and reducing mental health issues may have a significant influence on this population (Feng et al., 2014; Zhai et al., 2021). Physical activity (PA) and sleep are both important aspects of a healthy lifestyle. PA is counted as an important factor to improve sleep quality (Ma et al., 2020). The purpose of this literature review was to find, summarize, and evaluate the relationship between physical activity and sleep quality.

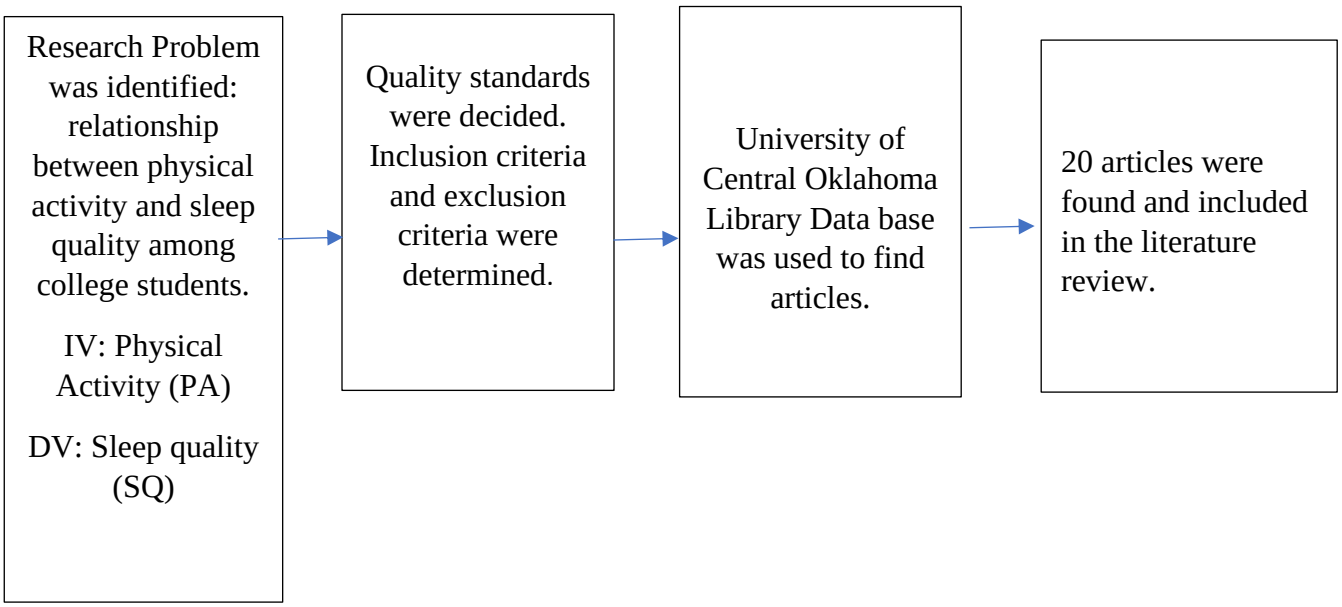
Methods

The present study is a review of articles which were published between 2012 and 2022 studying the relationship of PA and sleep quality among college students. In order to find articles, the University of Central Oklahoma library database was searched. Articles were taken from journals such as *PLOS ONE, HOLISTIC NURSING PRACTICE, F1000RESEARCH, SUSTAINABILITY, MENTAL HEALTH AND PHYSICAL ACTIVITY, RESEARCH IN SPORTS MEDICINE, BMJ OPEN, INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH, BMC SPROTS SCIENCE, MEDICINE AND REHABILITATION, JOURNAL OF BEHAVIOR MEDICINE, CLOCKS & SLEEP, SLEEP BIOLOGICAL RHYTHM, CUREUS, INTERNATIONAL ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH, NATURE AND SCIENCE OF SLEEP, VASCULAR HEATH AND RISK MANAGEMENT* . In order to maintain quality standards, those articles which were published between 2012 and 2022 and those who discussed the relationship between PA and sleep or the effect of PA on sleep were included. Articles which were not peer reviewed and were not available in full text were excluded. For quality criteria, articles that included all the inclusion variables were considered

strong. Articles that included only one inclusion variable considered weak. A total of 20 articles were found and selected for this literature review (Figure 1), in which 18 were strong and two were weak based on quality criteria.

Figure 1

Flow-chart Explaining the Methodology of Literature Review



Results

Table 1

Data Extraction Sheet includes Purpose, Participants, Type, Methods and Variable of Study

Study Topic	Article Citation	Purpose	Participants	Type of study	Methods
Associations of Physical Activity, Screen Time with Depression, Anxiety and Sleep Quality among Chinese College Freshmen	Feng et al., 2014	To look into the separate and combined effects of physical activity (PA) and screen time (ST) on depression, anxiety, and sleep quality in Chinese college students.	College freshmen Male=635, Female= 471, age= 18.9±0.9 years	Survey	Self-administered questionnaires were used to collect information on the students' PA, ST, and socioeconomic status. The Pittsburgh Sleep Quality Index was used to assess sleep quality (PSQI). The Self-rating Depression Scale (SDS) and the Self-rating Anxiety Scale (SAS) were used to assess depression and anxiety, respectively.
Mediating Effect of Perceived Stress on The Association Between Physical Activity and Sleep Quality Among Chinese College Students	Zhai et al., 2021	The purpose of this study was to see if stress had a mediating influence on the relationship between physical activity and sleep quality in Chinese college students.	College students Male=4752, Female= 2221, age= 19.0±0.9 years	Experiment	The participants were asked to complete the International Physical Activity Questionnaire—Short Form (IPAQ), Perceived Stress Scale—10 Items (PSS-10), and Pittsburgh Sleep Quality Index (PSQI) before and after one week.

Low Physical Activity and High Screen Time Can Increase Risks of Mental Health Problems and Poor Sleep Quality Among Chinese College Students	Wu et al., 2015	The study's major goal was to explore how physical activity (PA) and screen time (ST) affect Chinese college students' self-reported mental health and sleep quality.	College students Male=41.6%, Female= 58.4%, age= 19.24±1.41 years	Cross sectional survey	To see if there are any independent or interacting physical relationships. During a 20–30-minute period, a self-administered questionnaire encompassing information on sociodemographic factors, height, weight, PA, ST, mental health, and sleep quality was administered.
Associations Of Physical Activity and Screen Time with Suboptimal Health Status and Sleep Quality Among Chinese College Freshmen: A Cross-Sectional Study	Ma et al., 2020	The purpose of this study was to look at the links between physical activity (PA) and screen timWe (ST) and physiological, psychological, and social health in Chinese college freshman, with a focus on sleep quality.	College Freshmen Male=1833, Female= 3400, age= 21.74±3.58 years	Cross sectional survey	Using the IPAQ-SF and, PSQI participants filled out a self-report questionnaire about their demographic characteristics, nicotine and alcohol use, PA, ST, sleep quality, and health status.
Physical Activity and Sleep Quality in Students of The Faculty of Physical	Badicu, 2018	The goal of this study was to determine the level of physical activity (PAL) and sleep quality	college students, Male= 255, female=139, age= 18-25 years	Survey	All participants were asked to fill questionnaires. The Pittsburgh Sleep Quality Questionnaire (PSQI) was used to measure sleep quality and the short form of the

Education and Sport of Brasov, Romania		among students at Brasov's Faculty of Physical Education and Sport.			International Physical Activity Questionnaire Short Form (IPAQ) was utilized to assess PAL.
Associations Among Physical Activity and Smartphone Use with Perceived Stress and Sleep Quality of Chinese College Students	Zhai et al., 2020	After controlling for any confounding factors, the main purpose of the study was to see if there was a link between physical activity and smartphone use and sleep quality and felt stress.	College students, Total= 3864 Male= 2667, female=1197 , age= 19.5±0.9 years	Survey	All participants were asked to fill questionnaires. The Pittsburgh Sleep Quality Questionnaire (PSQI) was used to measure sleep quality and the shot form of the International Physical Activity Questionnaire Short Form (IPAQ-SF) was utilized to assess PA; perceived stress scale was used to measured stress.
Effects Of A 12-Week Physical Activities Programmed on Sleep in Female University Students	Hurdiel et al., 2017	The study's major goal was to see if sedentary female students' sleep could be improved by engaging in regular physical activities.	College students, female= 19, control group (CG)= 9, intervention group (IG)= 10	Experiment	Nineteen female students who were characterized as inactive and with poor subjective sleep quality were randomly allocated to one of two groups: a 12-week university physical activities program based on WHO recommendations (N = 10) or a control condition (N = 9). Actigraphy was used to assess sleep before and after the study, as well as the Pittsburg Sleep Quality 15 Index (PSQI) at the start, middle, and finish. A heart rate monitor was used

					to regulate the intensity of physical exercises.
Physical Activity, Perceived Stress, Sleep and Mental Health Among University Students From 23 Low- and Middle-Income Countries	Pengpid & Peltzer, 2018	The purpose of the study was to see if there were any cross-sectional links between vigorous physical activity (VPA), perceived stress, sleep quality and quantity, and mental health among university students.	University students, Total= 15122 Male= 42.1%, female=57.9 %, age= 20.6±2.0 years	Survey	Data was obtained from 15122 (42.1 percent male and 57.9% female) university students [mean age 20.6, standard deviation (SD) = 2.0] from 23 countries in the Americas, Africa, and Asia in a cross-sectional study utilizing anonymous questionnaires. The International Physical Activity Questionnaire (short version) was used to assess them, as well as sociodemographic, health status, health behavior, and anthropometric data.
Associations Between Sleep Quality And Its Domains and Insufficient Physical Activity in A Large Sample of Croatian Young Adults: A Cross-Sectional Study	Stefan al., 2018	The major goal of this study was to look at the links between poor sleep quality and a lack of physical activity.	University students, Total= 2100 Male= 1049, female=105, age= 18-24 years	Cross sectional survey	Researchers employed the previously validated Pittsburgh Sleep Quality Index and International Physical Activity questionnaires to assess the dimensions of sleep quality (independent variables) and 'insufficient' physical activity (dependent variable). The relationships between sleep quality and 'insufficient' physical activity were calculated using logistic regressions.

Relationships Between Depression, Daily Physical Activity, Physical Fitness, and Daytime Sleepiness Among Japanese University Students	Shimamoto et al., 2021	The study's major goal was to see if there was a link between mental health, physical exercise, fitness, and daytime sleepiness.	Undergraduate University students, Total= 85 Male= 52, female= 33, age= 18.9±1.4 years	Experimental	For two weeks, an accelerometer (Life order, Kenz, Nagoya, Japan) was used to track physical activity. Maximal oxygen uptake (VO2max) was assessed using an indirect method on a cycle ergometer to assess their degree of physical fitness. The Patient Health Questionnaire was used to assess depressive tendencies and daytime drowsiness (PHQ-9).
Physical Activity Level, Insomnia and Related Impact in Medical Students in Poland	Galas et al., 2021	The goal of this study was to find out how common insomnia is among medical students, as well as to look at physical activity levels and other behavioral characteristics linked to insomnia in this group.	Medical students, Total= 308 Male= 133, female= 175, age= 18-35years	Survey	The Athens Insomnia Scale (AIS) was used to assess insomnia among students and the International Physical Activity Questionnaire (IPAQ) was utilized to assess physical activity levels. Variables associated to insomnia were studied using a multifactor model of analysis.
Association of Physical Activity and Sleep Quality with	Satti et al., 2019	The study's goal was to evaluate sleep quality and physical activity levels among	University fourth year MBBS students, Total= 219	Survey	The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep quality, the Global Physical Activity Questionnaire (GPAQ) was

Academic Performance Among Fourth-Year MBBS Students of Rawalpindi Medical University		Rawalpindi Medical University's fourth-year MBBS students.	Male= 94, female=125.		used to examine physical activity levels, and academic achievement was determined by the grades earned on the most recent pathology class examination. Students who were unable to prepare for the test in the customary way were not included in the study. A total of 219 students were included in the final study sample. The variables were evaluated using a chi-squared test, independent samples t-test, Pearson's correlation, and a multiple linear regression model.
Effects of Sleep Deprivation on Cognitive and Physical Performance in University Students	Patrick et al., 2017	The goal of this study was to see how a night of sleep deprivation affected students' cognitive and physical performance.	University students, Total= 64 Male= 37, female= 26, age= 22±4 years	Randomized controlled crossover study	Normal sleep or one night of sleep deprivation were the two conditions that participants were randomly assigned to. The participants' residences were used to complete a time-stamped online questionnaire at 45-minute intervals to track their sleep quality. The outcomes were physical, including reaction time (ruler drop testing), lung function (spirometry), rate of perceived exertion, heart rate, and blood

					pressure during submaximal cardiopulmonary exercise testing, and cognitive, including working memory (Simon game derivative) and executive function (Stroop test).
Exploring Relationships of Sleep Duration with Eating and Physical Activity Behaviors Among Canadian University Students	Papaconstantinou et al., 2020	The primary purpose of this study was to look at the links between sleeping habits and eating and physical activity habits in a group of undergraduate health science students.	University students, Total= 245, age= 18-26 years	Survey	A cross-sectional strategy was used to recruit undergraduate health sciences students from a small Canadian university to answer an online questionnaire included PSQI, IPAQ and questions about their eating, sleeping, and physical activity habits. Important sociodemographic details as well as information on self-reported height and weight were recorded.
Replacing Sedentary Time with Sleep, Light, Or Moderate-To vigorous Physical Activity: Effects on Self-Regulation and Executive Functioning	Fanning et al., 2016	The goal of this cross-sectional study was to see how replacing 30 minutes of sedentary behavior with 30 minutes of mild activity, moderate-to-vigorous physical activity (MVPA), or sleep affects	University students, Total= 247, age= 18-26 years	Experiment	The participants were assigned to one of two groups: normal sleep or one night of sleep deprivation. Sleep deprivation was tracked using an online time-stamped questionnaire completed in the participants' residences at 45-minute intervals. During submaximal cardiopulmonary exercise testing, the outcomes were cognitive: working memory

		self-regulatory and executive functioning.			executive function (Stroop test), and physical: response time (ruler drop testing), lung function (spirometry), rate of perceived exertion, heart rate, and blood pressure. MANOVA and single paired two-tailed T tests were used to analyze the data.
The Effect of Regular Aerobic Exercise n Sleep Quality and Fatigue Among Female Student Dormitory Residents	Ezati et al., 2020	The purpose of this study was to see how regular aerobic exercise affects sleep quality and exhaustion in female students who live in dorms.	University female students, Total= 67 age= 18-26 years	Experiment	One experimental group (given aerobic exercise) and one control group comprised the 67 participants in this quasi-experimental study (i.e., not assigned aerobic exercise). For eight weeks, participants in the experimental group were given three one-hour sessions of aerobic exercise ranging from mild to moderate intensity. The Pittsburgh Sleep Quality Index (PSQI) and the standard Multidimensional Exhaustion Inventory (MFI-20) were used to assess sleep quality and fatigue levels, respectively. These variables were measured at the beginning of the trial, week four, and week eight.
Effects of A Physical Activity and	Choi et al., 2018	The purpose of the study was to determine to see	College students, 63 participants.	Experiment	The 9-week, 3-level PASB program was guided by the 7 components of the model of

Sedentary Behavior Program on Activity Levels, Stress, Body Size, And Sleep in Sedentary Korean College Students		the effects of a physical activity on body size, activity levels, stress on sleep.	Control group= 30, experimental group= 33. age= 21.2±2.63 years		PA and health outcomes19. The program was divided into three levels: (1) individual level: exercise tracking with a wearable activity tracker and counseling on goal-setting, plan restructuring, and relapse prevention; (2) group level: group education, exercise training, group discussion, and small-group exercise to demonstrate the benefits of exercise, self-efficacy, and social support; and (3) university level: membership at a campus sport facility to provide access to an exercise environment.
Sleep Quality Among Undergraduate Students of a Medical College In Nepal During COVID-19 Pandemic: An Online Survey	Shrestha et al., 2021	This study attempts to determine the impact of the COVID-19 pandemic's massive change on the sleep quality of medical students at a Nepalese medical college during the epidemic.	College students, Male= 32, female= 17, age= 21.2±2.63 years	Survey	The method employed was stratified random sampling. The Pittsburgh Sleep Quality Index was used to collect data (PSQI). Completed questionnaires were included, and STATA vs. 15 was used to analyze them.

Association Between Sleep Quality and Physical Activity in Saudi Arabian University Students	Mahfouz et al., 2020	This purpose of the study was to see the link between poor sleep quality and physical inactivity among Saudi Arabian students at Jazan University.	University students, Total= 440 Male=215, female=225, age= 18.9±1.4 years	Survey	At Japan University, an observational cross-sectional study was undertaken among undergraduate students. 440 students were chosen using cluster random sampling. Data was collected using the Pittsburgh Sleep Quality Index (PSQI), the International Physical Activity Questionnaire (IPAQ), and the Depression Anxiety Stress Scales (DASS).
Effects of Exercise Timing on Sleep Architecture and Nocturnal Blood Pressure in Prehypertensive	Fairbrother et al., 2014	The goal of this research was to see how aerobic exercise scheduling affected circadian BP variations and sleep architecture.	University students, Total= 20, age= 20-30years	Experiment	The study was completed by twenty prehypertensive people. Participants conducted a graded exercise test to exhaustion before performing 30 minutes of treadmill exercise at 65 percent of their maximum heart rate attained at peak oxygen uptake at 7 a.m. (7A), 1 p.m. (1P), and 7 p.m. (7P) in a random, counterbalanced order during four test sessions. Following each session, an ambulatory cuff was used to record blood pressure responses for 24 hours after exercise, and an ambulatory sleep-monitoring headband was worn during sleep.

Table 2

Data Extraction Sheet Includes Results, Main Conclusion, Gaps and Limitations of Study

Study Topic	Article Citation	Results	Main Conclusions	Gaps	Limitations
Associations of Physical Activity, Screen Time with Depression, Anxiety and Sleep Quality among Chinese College Freshmen	Feng et al., 2014	Low ST and high PA were linked to lower chances of poor sleep quality (OR: 0.48, 95 percent CI: 0.30–0.78) and depression (OR: 0.67, 95 percent CI: 0.44–0.89), respectively. The combined effects of PA and low ST on depression (OR: 0.62, 95 percent CI: 0.40–0.92) and sleep quality (OR: 0.51, 95 percent CI: 0.27–0.91) showed an interaction adverse relationship. There were no statistically significant links between PA, ST, and anxiety among the subjects.	These findings imply that high PA and low ST have an independent and interactive connection with a lower frequency of depressive issues and better sleep quality among Chinese college freshmen.	No gaps noted	Due to the current study's cross-sectional methodology, they were unable to draw a causal direction. Second, despite the fact that mental health issues and poor sleep quality were present, these measurements were not based on standardized questionnaires. As a result, future studies utilizing diagnostic tools will be comparable to clinical diagnosis. Interviews should be used wherever possible. Finally, because the PA and ST levels were self-reported, recollection and reporting bias cannot be ruled out. Fourth, PA intensity and leisure-time indicators were not included in the analysis. The use of a smart phone was not included in the ST definition, and Its unclear which forms of ST are significant.
Mediating Effect of Perceived Stress on The	Zhai et al., 2021	Males and females both had partial and complete mediating effects of perceived	Physical activity may help people sleep better by assisting them in coping with stress,	No gaps noted	PA, perceived stress, and SQ metrics were self-reported. This could have led to errors in recording, recollection, and social

Association Between Physical Activity and Sleep Quality Among Chinese College Students		stress on the relationship between physical activity and sleep quality, with 42.4 percent (partial mediating effect) and 306.3 percent (complete mediating effect) as percentages of mediation, respectively	implying that stress management could be a useful non-pharmaceutical sleep aid.		desirability bias, all of which could have harmed the study's reliability and validity. While confounding factors such as age, nationality, and tobacco and alcohol use were taken into account, more comprehensive data, such as body composition, cardiorespiratory fitness, and appetite, should be added.
Low Physical Activity and High Screen Time Can Increase Risks of Mental Health Problems and Poor Sleep Quality Among Chinese College Students	Wu et al., 2015	Poor sleep quality was found to be prevalent in 9.8% of the population. Anxiety (OR=1.38, 95 percent CI: 1.15-1.65), depression (OR=1.76, 95 percent CI: 1.47-2.09), psychopathological symptoms (OR=1.69, 95 percent CI: 1.43-2.01), and poor sleep quality (OR=1.32, 95 percent CI: 1.06-1.65) were all significantly linked with high ST. Anxiety, depression, psychopathological symptoms, and poor sleep were all found to	Interventions are required to lower ST and promote PA in young people's lifestyles. Future study should focus on developing and measuring the effects of interventions on sleep, health, and well-being.	No gaps noted	The fact that the PA and ST levels were assessed using self-reported questionnaires was a constraint that may have influenced our findings; hence, recall and reporting biases could not be prevented. the PA question did not describe the type or degree of PA. Finally, our study looked at anxiety, depression, and symptoms rather than clinically confirmed depression, so results may vary.

		be negatively related with high PA.			
Associations Of Physical Activity and Screen Time With Suboptimal Health Status And Sleep Quality Among Chinese College Freshmen: A Cross-Sectional Study	Ma et al., 2020	Poor sleep quality was found to be prevalent in 37.94 percent of the population. High ST and PA were linked to physiological suboptimal health status (aOR = 1.39, 95 percent CI: 1.16–1.68, and aOR = 0.55, 95 percent CI: 0.45–0.71), psychological suboptimal health status (aOR = 1.43, 95 percent CI: 1.21–1.69, and aOR = 0.57, 95 percent CI: 0.47–0.79), social suboptimal health status (aOR = 1.27, 95 percent CI: 1.08– Low ST and high PA were also linked to poor sleep quality (aOR = 0.56, 95% CI: 0.45–0.70), physiological suboptimal health status (aOR = 0.49, 95% CI: 0.40–0.59), psychological suboptimal health	Low ST and high PA have independent and interaction relationships with poor sleep quality and poor health status among Chinese college freshman.	It was self-reported study.	The types of screen-based activities, duration, and intensity of PA were not assessed in this study, which only analyzed the frequency of ST and PA. As a result, the connections may be more intricate. Standardized questionnaires were used to assess the presence of poor sleep quality and physiological, psychological, and social suboptimal health status, which may not be as reliable as clinical diagnosis.

		status (aOR = 0.48, 95% CI: 0.39–0.58), and social suboptimal health status (aOR = 0.49, 95% CI: 0.40–0.59).			
Physical Activity and Sleep Quality in Students of The Faculty of Physical Education and Sport of Brasov, Romania	Badicu, 2018	Poor sleep quality was found to be prevalent in 37.94 percent of the population. High ST and PA were linked to physiological suboptimal health status (aOR = 1.39, 95 percent CI: 1.16–1.68, and aOR = 0.55, 95 percent CI: 0.45–0.71), psychological suboptimal health status (aOR = 1.43, 95 percent CI: 1.21–1.69, and aOR = 0.57, 95 percent CI: 0.47–0.79), social suboptimal health status (aOR = 1.27, 95 percent CI: 1.08– Low ST and high PA were also linked to poor sleep quality (aOR = 0.56, 95% CI: 0.45–0.70), physiological suboptimal health	Low ST and high PA have independent and interaction relationships with poor sleep quality and poor health status among Chinese college freshman.	It was self-reported study.	The types of screen-based activities, duration, and intensity of PA were not assessed in this study, which only analyzed the frequency of ST and PA. As a result, the connections may be more intricate. Standardized questionnaires were used to assess the presence of poor sleep quality and physiological, psychological, and social suboptimal health status, which may not be as reliable as clinical diagnosis.

		status (aOR = 0.49, 95% CI: 0.40–0.59), psychological suboptimal health status (aOR = 0.48, 95% CI: 0.39–0.58), and social suboptimal health status (aOR = 0.49, 95% CI: 0.40–0.59).			
Associations Among Physical Activity and Smartphone Use with Perceived Stress and Sleep Quality of Chinese College Students	Zhai et al., 2020	Participants who engaged in adequate physical activity had lower felt stress (male students, *P*=0.01; female students, *P*= 0.01; total students, *P*= 0.01; total students, *P*= 0.01) and improved sleep quality (male students, *P*= 0.01; female students, *P*=0.05; total students, *P*=0.01). Meanwhile, heavy smartphone users showed greater levels of perceived stress (male students, *P*= 0.01; female students, *P*= 0.01; total students, *P*= 0.01) and lower sleep quality	Increased physical activity and reduced smartphone use should be the goals of therapies to improve sleep quality and reduce perceived stress in college students.	No gaps noted	Not noted

		(male students, *P*= 0.01; female students, *P*= 0.01; total students, *P*= 0.01) than light and medium smartphone users.			
Effects of A 12-Week Physical Activities Programmed on Sleep in Female University Students	Hurdiel et al., 2017	For moderate and severe levels of PA, there was an interaction between group and time (Moderate: F1,17 = 31.9, *P*= 0.001, 2 = 0.22; Intense: F1,17 = 19.9, *P*= 0.001, 2 = 0.12). The PA group met the WHO weekly recommendations for the amount and intensity of PA, but not the CON group (PA vs. CON; Moderate: 96 23 min vs. 26 43 min; Intense: 100 21 min vs. 53 53 min).	These preliminary findings suggest that a physical activity program for students is feasible to execute, and that participation in such a program improves sleep among female adolescents aged 18 to 24.	No gaps noted	Researcher did not focus on menstruation history of participants since it might affect the sleep quality and adherence to physical activity.
Physical Activity, Perceived Stress, Sleep And Mental Health Among	Pengpid & Peltzer., 2018	Students who followed the VPA suggestions were less likely to report perceived stress and more likely to report subjective good	This study only discovered limited effects of VPA in terms of university students' well-being.	No gaps noted	No causal implications can be inferred because the study was cross-sectional. The survey was done with students from one university in each country, and the findings could

University Students From 23 Low-And Middle-Income Countries		health and despair than students who did not follow the VPA recommendations. There was no link between VPA and PTSD symptoms or sleep quality or quantity.			have been different if other universities had been included. VPA and its correlates may differ in other segments of the population, as university students are not indicative of young people in general. Furthermore, the findings may have been skewed by the inclusion of self-reported evaluation variables such as PA and sleep pattern.
Associations Between Sleep Quality And Its Domains and Insufficient Physical Activity in A Large Sample of Croatian Young Adults: A Cross-Sectional Study	Stefan et al., 2018	When the sleep quality domains were entered separately into the model, very poor subjective sleep quality (OR 3.09; 95 percent CI 1.50 to 6.56), >60min of sleep latency (OR 2.17; 95 percent CI 1.39 to 3.39), 7 hours of sleep (OR 1.56; 95 percent CI 1.24 to 1.96), 65% of habitual sleep efficiency (OR 2.26; 95 percent CI 1.26 to 4.05), sleep disturbances >1/week (OR 1.61; 95 percent CI 1.03	The findings revealed that 'poor sleep quality' was linked to 'insufficient' physical exercise.	No gaps noted	Researchers assessed both dependent and independent variables using subjective measures (questionnaires), which could have resulted in bias. They are unable to determine the direction of the associations due to the cross-sectional design.
Relationships Between	Shimamoto et al., 2021	Sleepiness ($r = 0.35$, $P = 0.001$) and total	These findings show that strenuous physical	Because the kind,	Future studies should take into account the severity of

Depression, Daily Physical Activity, Physical Fitness, and Daytime Sleepiness Among Japanese University Students		steps per day (r = 0.39, p 0.001) were both positively connected with the PHQ-9 score. Furthermore, the PHQ-9 score was found to have a favorable relationship with VO2max (r = 0.25, *P* = 0.019). Students with good exercise routines or part-time jobs had a better PHQ-9 score. The significant association between depression and variables related to physical activity levels was a key finding.	activity, such as exercise and part-time work, may be linked to depressed tendencies in university students.	intensity, duration, and timing of the physical activity in which individuals took part were unclear, their effect could not be assessed; further research into the type, intensity, duration, and timing of the physical activity is required.	extracurricular activities and part-time occupations, which were not taken into account in this study. Second, the study's small sample size and demographics have an impact on the study's expansion and generalizability. Our findings cannot be extended to people of various ages or ethnicities because all of the participants were Japanese first-year university students. Third, participants' physical activity may have increased as a result of wearing a pedometer. As a result, it's likely that this study's physical activity data included the influence of being measured with an accelerometer.

Physical Activity Level, Insomnia and Related Impact in Medical Students in Poland	Galas et al., 2021	Inactive medical students made up 19.2 percent of the total. Insomnia was mentioned by 36.8% of the students. Smoking cigarettes (ß = 0.21, p = 0.001), taking energy drinks several times a month (ß = 0.21, p = 0.024), and everyday stress (ß = 0.44, p 0.001) all had a detrimental impact on the quality of sleep of medical students in the multifactorial model.	Although the majority of medical students are physically active, about one-third of them suffer from insomnia. Students who are under constant stress or who consume cigarettes are more likely to have sleep problems.	No gaps noted	Because the study population is a convenience sample of students from a single medical university, the findings should be regarded with caution. As a result, the findings may not be applicable to students at other universities. Second, gender (women), low socioeconomic position, cigarette smoking, everyday stressful conditions, and subjectively rated PA all influenced insomnia, but many other characteristics including sleep disorders, which could potentially complicate the diagnosis of insomnia, were not considered. Third, stress was measured by asking students how often they were stressed, which may be skewed when compared to research that used diagnostic interview methods.
Association of Physical Activity and Sleep Quality with Academic Performance Among Fourth-Year	Satti et al., 2019	Academic performance was substantially connected with sleep quality and physical exercise (p-values of the chi-square and t-test were 0.000). With test scores,	Both the PSQI and GPAQ scores are substantially connected with test scores and can be used to identify areas where students might enhance their exam performance.	No gaps noted	Not noted

MBBS Students of Rawalpindi Medical University		Pearson's correlation value was -0.69 for PSQI (p0.000) and 0.62 for GPAQ (p 0.003). Gender had a significant relationship with sleep and physical activity levels (male students were more active and had poorer sleep quality than female students), but not with test scores. All three variables have a strong relationship with boarding status. In comparison to non-boarders, boarders had lower mean test scores and lower sleep and physical activity indices. With beta coefficients of -2.53 (p=0.002) for sleep quality and 1.37 (p=0.01) for physical activity, the multiple linear regression model was valid (p-value of the F test was			

		0.000). R2 was 84%.			
Effects of Sleep Deprivation on Cognitive and Physical Performance in University Students	Patrick et al., 2017	After sleep deprivation, reaction time and systolic blood pressure both increased significantly (mean SD change: reaction time: 0.150.04 s, p=0.003; systolic BP: 617 mmHg, p=0.012). Other variables revealed no significant differences. Sleep deprivation significantly affected reaction time and vascular reactivity to exercise in university students, whereas other cognitive and cardiovascular tests revealed no significant alterations.	These data suggest that acute sleep deprivation can affect physical ability but not cognitive ability in young, healthy university students.	No gaps noted	When interpreting the findings of this study, certain limitations must be acknowledged. First, rather than being supervised, individuals spent their night of sleep deprivation in an environment of their choosing. As a result, the study relied on self-reported sleep deprivation and form completion, which could suggest that some students got more sleep on the sleep deprivation night than others. While this limits the generalizability of our findings in larger samples, the findings are indicative of the effects of acute sleep loss on higher education students.
Exploring Relationships of Sleep Duration with Eating and Physical Activity Behaviors	Papaconstantinou et al., 2020	The participants (n = 245) were on average 23 years old, 86 percent of whom were female, and the majority of whom were full-time students (92 percent).	The findings underscore the need for on-campus wellness services to be expanded in order to encourage healthy sleeping habits in a susceptible university population.	Food insecurity was not assessed in this study; however	Because of the limited sample size and exploratory character of this study, no clear conclusions concerning the relationships between sleep, eating, and physical activity patterns can be drawn. This study simply identifies connections, not causal

Among Canadian University Students		The mean BMI was within a healthy range (mean=24.58 SD= 5.55), and the majority of the participants reported low levels of physical activity (65 percent). Despite self-reported very or rather good sleep quality (65%), the mean global sleep scores (scores > 5, mean 7.4, SD 3.3) suggested poor overall sleep quality. Higher BMIs were linked to poorer sleep quality (r = 0.265, p<0.001).		, future research should investigate addressing this emerging area because food insecurity can operate as a mediator factor in the link between sleep and eating behaviors.	implications, due to its exploratory character. In this developing field, more longitudinal investigations are required. The low response rate in this study may be due to a labor disruption that occurred around the time of the survey's commencement.
Replacing Sedentary Time with Sleep, Light, Or Moderate-To vigorous Physical Activity: Effects On Self-	Fanning et al., 2016	The use of self-regulatory strategies and executive functioning were altered when inactive time was replaced with sleep and MVPA. Self-monitoring (B =.23, *P* =.02), goal-	There were no significant impacts when light intensity physical activity was substituted. Individuals can improve numerous essential aspects of self-regulatory behavior and	No gaps noted	Although the current study collected performance measures of working memory and task switching, it did not collect assessments of inhibition. Because people must continually resist the urge to engage in habitual activities, including measures of inhibition in future research will be

Regulation And Executive Functioning		setting (B =.32, *P*=.01), and social support (B =.18, *P* =.01) behaviors were also linked to sleep. Higher accuracy on 2-item (B =.03, *P* =.01) and 3-item (B =.02, *P* =.04) spatial working memory tasks, as well as faster response times on single (B = -23.12, *P* =.03) and mixed-repeated task-switching blocks (B = -27.06, *P* =.04) task-switching blocks (B = -27.06, *P* =.04) task-s Sleeping in place of sedentary time resulted in a slightly faster reaction time on mixed-repeated task-switching blocks (B = -12.20, *P* =.07) and a significantly faster reaction time on mixed-switch blocks (B = 17.21, *P* =.0.05).	executive functioning by substituting sleep and MVPA for sedentary time.		beneficial. Similarly, in the current study, participants only wore activity monitors during awake hours.
The Effect of Regular Aerobic Exercise n	Ezati et al., 2020	Participants in the aerobic group improved their sleep quality and its	Sleep duration was unaffected by a four-week mild-intensity aerobic exercise	No gaps noted	The discrepancies in study participants' daily sleep hours and daily routines must be taken into

Sleep Quality and Fatigue Among Female Student Dormitory Residents		components (except for sleep length after four weeks of intervention) after four and eight weeks of intervention (*P* =0.001 and *P* =0.0001, respectively). In addition, compared to the control group, aerobic activity resulted in a substantial reduction in the total score of fatigue and its dimensions in weeks four and eight (*P*= 0.001).	program. In contrast, 8 weeks of intense aerobic exercise had a positive impact on all aspects of sleep quality.		account when interpreting the results.
Effects of A Physical Activity and Sedentary Behavior Program on Activity Levels, Stress, Body Size, And Sleep in Sedentary Korean College Students	Choi et al., 2018	Total PA scores, t = 2.00, *P* =.043, and step counts, t = 2.16, *P*=.034, in the experimental group increased significantly more than those in the control group after the intervention, while SB, t =.01, waist circumferences, t = 2.6, *P* =.01, and stress levels, t = 1.9, =.05, in the experimental group decreased	The program boosted physical activity and step counts while decreasing sedentary behavior, waist circumference, and obesity as well as stress levels	No gaps noted	There were some limitations to the study. It was a nonrandomized study, for example, which limited internal validity. Furthermore, because the study period was brief, it was difficult to predict if the findings regarding PA and SB would hold up over time. Furthermore, the sample consisted of college students from a specific region, limiting the data' generalizability.

		significantly more than those in the control group. Total PA scores (d = 0.50), sitting time durations (d = 0.68), step counts (d = 0.54), waist circumferences (d = 0.65), and stress levels (d = 0.48) all had moderate effect sizes (Cohen's d). BMI readings had fallen marginally in the experimental group and significantly in the control group by the end of the program; nevertheless, the difference between the two groups was not significant.			
Sleep Quality Among Undergraduate Students of a Medical College In Nepal During COVID-19 Pandemic: An Online Survey	Shrestha et al., 2021	Females had substantially greater odds of poor sleep quality (OR, 2.25; CI, 1.14-4.43) than males, according to unadjusted logistic regression analysis, and the relationship remained after correcting for age and	According to results, more than a quarter of medical students report poor sleep quality. As a result, medical students should be educated and made aware of the negative impacts of insufficient sleep on daily activities, physical and mental well-being,	It was online survey.	They employed a questionnaire that required participants to self-report. As a result, a key risk for this study is information bias. Our research focused on a particular institution's students. As a result, the findings may not apply to all of Nepal's medical schools. Similarly, recollection bias and subjectivity prejudice may have influenced our findings.

		year in medical school (aOR, 2.81; CI, 1.35-5.86). Using an unadjusted logistic regression analysis, there was no significant variation in sleep quality across years in medical school. When age and gender were taken into account, 4th-year MBBS students had an 82 percent lower chance of experiencing poor sleep quality than 2nd-year MBBS students (aOR, 0.18; CI, 0.04-0.76)	and general quality of life.		
Association Between Sleep Quality and Physical Activity in Saudi Arabian University Students	Mahfouz et al., 2020	The majority of responders (63.9 percent; n = 281) reported poor sleep quality, according to the PSQI data. Physical inactivity was also prevalent among students (62.7 percent; n = 276). The majority of pupils (53.4 percent) were stressed, according to	The majority of Japan University students were physically inactive and had poor sleep quality. To encourage physical activity among university students, evidence-based preventative and treatment measures are required.	They used student reporting rather than more objective approaches like clinical tests to	Due to the difficulty in obtaining permission from other universities, they only looked into the relationship between physical activity and sleep quality at one Saudi institution.

		DASS-21 criteria. The quality of sleep varies considerably depending on the participants' level of physical activity (*P* = 0.01). 43.9 percent of physically active participants said they had good sleep quality. Physical activity levels had a substantial impact on sleep duration, daytime dysfunctions, and the overall PSQI (*P*= 0.05 for all). Physical activity was found to be substantially linked with good sleep quality (OR = 1.70, 95 percent CI 1.14–2.54, *P*=0.001) in a univariate analysis. Physical activity and good sleep quality were also found to be linked in multivariate logistic regression models (OR = 1.72, 95		conduct their research.	

		percent CI 1.15–2.56, *P* = 0.008).			
Effects of Exercise Timing on Sleep Architecture and Nocturnal Blood Pressure in Prehypertensive	Fairbrother et al., 2014	Aerobic exercise at 7A caused a higher drop in nocturnal systolic blood pressure than exercise at 1P or 7P, although the biggest drop in nocturnal diastolic blood pressure occurred after 7P. 7A also resulted in more time spent in deep sleep as compared to 1P.	These findings suggest that doing aerobic activity first thing in the morning may be the most effective way to improve nocturnal BP fluctuations and sleep quality.	No gaps noted	Not noted

Most of the articles (16) reviewed here support that PA has a positive effect on sleep. A total of 15 articles discussed the relationship between physical activity and sleep quality in which they used IPAQ and PSQI and found positive correlations between both variables. Of these, fourteen articles focused on college students and two articles included middle-aged and older individuals. One article focused on resistance training only.

On the contrary, four articles did not find any correlation between physical activity and sleep quality. These studies used IPAQ and PSQI as instruments; however, there were limitations. For example, the studies examine the relationship between physical activity and sleep quality among middle-age and older individuals and they did not consider other factors like stress and medications which may impact the results.

Discussion

A total of 20 articles were included in this literature review in which 16 articles support the positive relationship between physical activity (PA) and sleep quality (SQ). Fifteen articles examined the relationship without specification of intensity of PA by using IPAQ and PSQI as instruments. One article examined resistance exercise and SQ by using a self-administrated questionnaire. There were four articles which did not find positive relationship between PA and SQ.

Conclusion

The research overwhelmingly supports that PA either improves sleep quality or is positively related with SQ; however, there was only one literature who focused on relationship between light to moderate intensity and sleep quality. There are many limitations in this body of literature. First, the studies incorporate many different study designs with very few of them being experimental studies. Second, many of the studies assess the primary variables using self-

reported instruments which are likely to be less accurate than objective measures. Thirdly, most of the literature only focused on relationship between total PA and SQ. One strength of this body of literature are the fairly consistent use of the same validated instruments to measure the primary variables. In the future, experimental studies should be conducted to see the relationship between PA and SQ among college students. It is also recommended that future studies examine PA at different intensities in relationships to SQ.

Chapter Three: Methodology

Participants

Participants (n = 159) were voluntarily recruited from college students enrolled at the University of Central Oklahoma (UCO). The recruitment was done by email blast with survey link included. To target physically active students, recruitment was also conducted in specific physical activity classes.

Instrumentation

To measure the intensity of physical activity, the International Physical Activity Questionnaire (IPAQ) was used. IPAQ includes seven questions which ask about the amount of physical activity (walking, moderate, and vigorous) within the last seven days. For scoring, reported minutes of PA are converted to MET minutes per week using the MET value for each intensity of PA (walking = 3.3, moderate activity = 4, vigorous exercise = 8; Appendix A). In this study, walking PA was considered light PA. IPAQ is a well-known validated questionnaire with 77 % specificity (Ekelund et al., 2006; Tomioka et al., 2011)

In order to measure sleep quality (SQ), the Pittsburgh Sleep Quality Index (PSQI) was used. The PSQI consists of 21 self-reported questions. The 21 self-reported items are combined to create seven "component scores," each with a 0–3-point range. A number of "0" implies no difficulty, whereas a score of "3" indicates extreme difficulty. The seven component values are then summed together to produce a single "global" sleep quality score ranging from 0 to 21, with "0" indicating no difficulty and "21" indicating significant difficulty in all categories; thus, lower scores indicate less difficulty or better sleep quality (Appendix B). The global PSQI score was be used for analysis. PSQI has 98.7 % reliability and specificity of 84.4 % among people who complained of sleep disturbances and it is a validated questionnaire for evaluating sleep disturbances (Bakhuas et al., 2002).

Procedures

College students were asked to participate in this study by email blast and posted flyers. An online survey was used for ease and convenience. The first question of the online survey was the consent form. Those giving consent proceeded to the online version of the IPAQ and PSQI. Recruitment was also done from specific classes with permission of the instructor.

Design and Analysis

The data were scored according to the procedures outlined for each questionnaire. Four PA variables were calculated from the IPAQ: total PA, vigorous PA, moderate PA, and light PA. These four scores represent the volume of PA at that intensity measured in $MET \cdot min \cdot wk^{-1}$. The total PA score was the sum of the volume of vigorous PA, moderate PA, and light PA. The global score from the PSQI was used as the SQ variable for analysis. Data were analyzed using IBM SPSS (Version 28). Pearson correlation analyses were done to analyze the relationship between volume of PA at each intensity and SQ ($\alpha = .05$).

Further analyses were conducted by creating groups within the PA variables. At each intensity (vigorous & moderate) two groups were formed: those reporting no PA at that intensity and those reporting any PA at that intensity. Independent t-tests were conducted at each intensity to examine the difference in SQ between the two groups ($\alpha = .05$).

Using the moderate PA and vigorous PA variables, four groups were formed: (1) no vigorous PA and no moderate PA; (2) any moderate PA and no vigorous PA; (3) any vigorous PA and no moderate PA; and (4) any moderate PA and any vigorous PA. One-way ANOVA with pair-wise post-hoc tests was used to analyze the differences between the four groups ($\alpha = .05$).

The vigorous PA and moderate PA variables were further grouped using percentiles. Due to the large number of participants reporting no PA at each intensity, one group was formed of scores less than the 50th percentile. The second group was formed from scores between the 51st and 75th percentile, while the third group was formed from scores greater than the 75th percentile. This created three groups within the vigorous PA variable (no vigorous PA, low vigorous PA, and high vigorous PA) and the moderate PA variable (no moderate PA, low moderate PA, and high moderate PA. One-way ANOVA with pairwise post hoc tests was conducted within each intensity variable (vigorous PA and moderate PA) to analyze differences in SQ ($\alpha = .05$).

Chapter Four: Results

The main aim of the study was to analyze the relationship between volume of physical activity (PA) at different intensities and sleep quality (SQ). The relationship between total PA, vigorous PA, moderate PA and light PA intensities and SQ were analyzed. Of the 159 responses, 116 participants' data were used for analysis. Four outliers were removed due to inaccurate representation of their volume of different intensities and 39 responses were incomplete. As per data, 26.4 % were male, 71.1% were female and 0.6% were non-binary or 3rd gender, 0.6% were individuals who did not prefer to share their gender with the mean age of 24.5±0.5 years.

Descriptive Statistics

The volume of vigorous PA (945.6±166.9), moderate PA (828.4±147.8), light PA (1,746.1±277.8) and total PA (3,520.3±393.6) was measured in MET·min·wk^{-1}. Sleep quality was measured by PSQI scores (4.9±0.3; Table 1).

Table 1

Descriptive Statistics for Physical Activity (PA) and Sleep Quality (SQ)

	M	*SD*	Minimum	Maximum
Vigorous PA	945.6	166.9	0.0	12,960.0
Moderate PA	828.4	147.8	0.0	8640.0
Light PA	1,746.1	277.8	0.0	11,376.7
Total PA	3,520.3	393.6	0.0	16,408.7
SQ	4.9	0.3	0.0	15.0

Figures 1 to 5 depict the distribution of vigorous PA, moderate PA, light PA, total PA and SQ measures as PSQI global score. As per Figure 1, most of the individuals were not physically active with the same pattern seen for moderate physical activity (Figure 2) and light physical activity (Figure 3). As per data, 31.8% responders reported no vigorous and no

moderate PA. Most participants reported PSQI scores between 1 to 6. The frequency distribution of PSQI scores among participants is shown in Figure 5.

Figure 1

Frequency Distribution of Vigorous PA

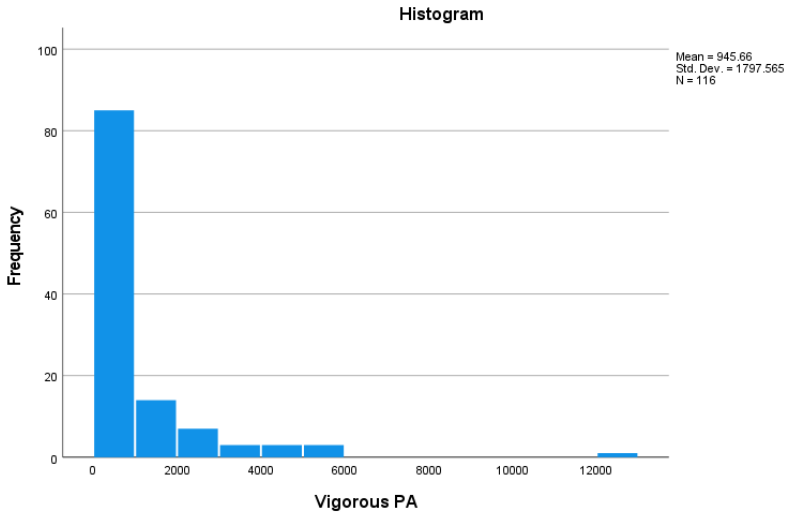


Figure 2

Frequency Distribution of Moderate PA

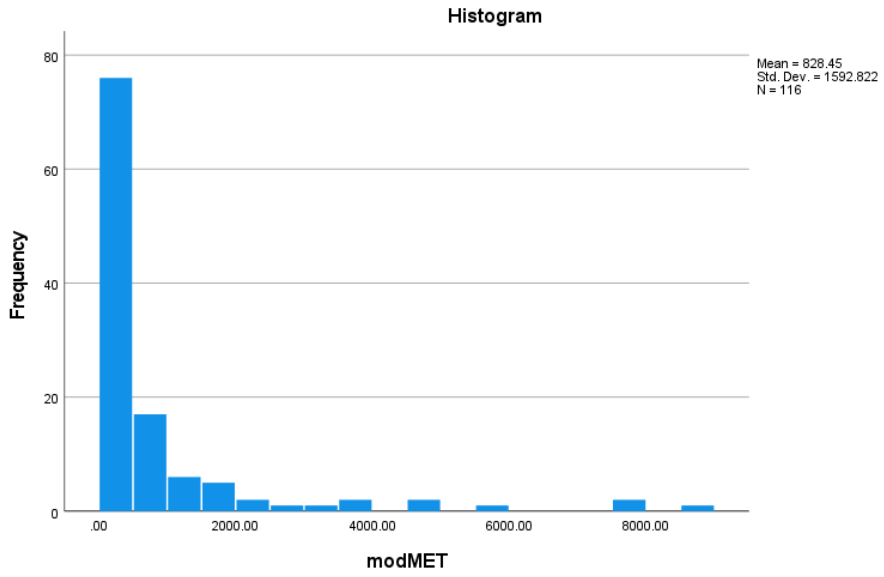


Figure 3

Frequency Distribution of Light PA

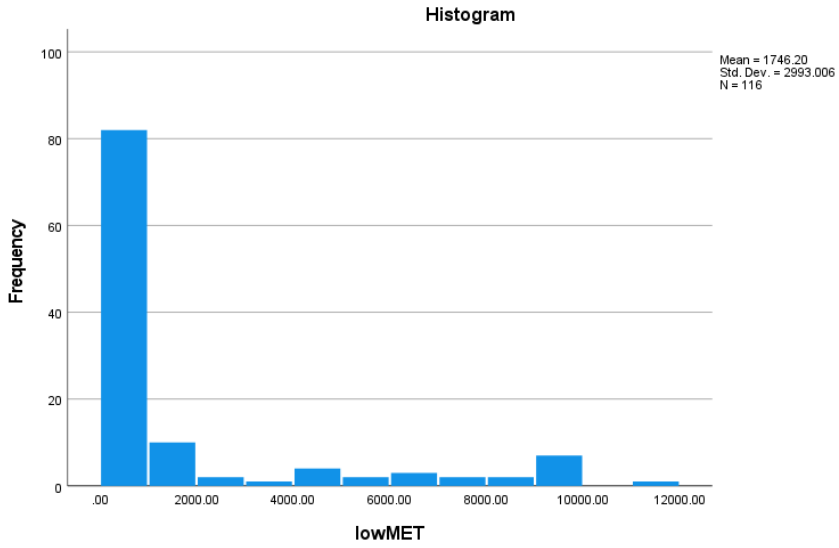


Figure 4

Frequency Distribution of Total PA

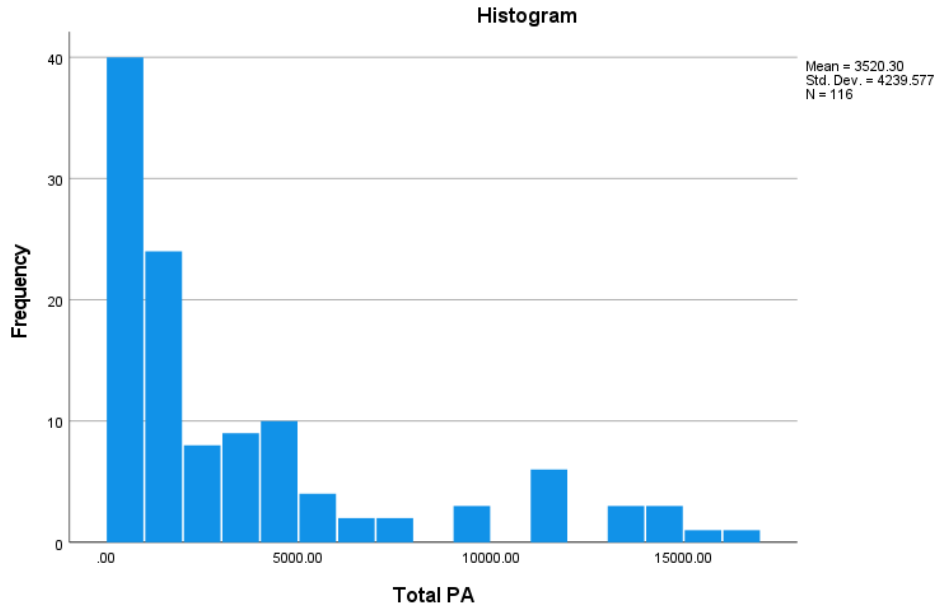
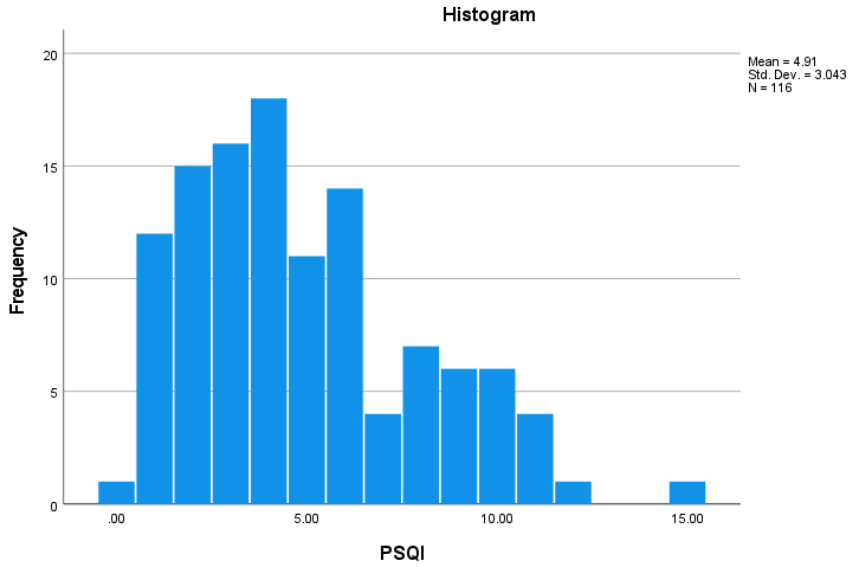


Figure 5

Frequency Distribution of PSQI Scores



Correlation Between PA and Sleep Quality

A Pearson correlation analysis was conducted between vigorous PA, moderate PA, light PA, total PA, and PSQI. The relationship between vigorous PA and PSQI was non-significant, indirect, and very weak (r =-.09, p =.29). The relationship between moderate PA and PSQI was non-significant, direct, and very weak (r =.06, p =.47). The relationship between light PA and PSQI was non-significant, direct, and very weak (r =.03, p =.70). The relationship between total PA and PSQI was non-significant, direct, and very weak (r =.02, p =.81). In summary, no significant correlation was found between PA and sleep quality ($p>.05$; Table 2).

Table 2

Correlations Matrix of Volume of Physical Activity and PSQI

Variable	1	2	3	4	5
1. Vigorous PA	-				
2. Moderate PA	-.07	-			
3. Light PA	-.01	.47*	-		
4. Total PA	.43*	.61*	.84*	-	
5. PSQI	-.09	.06	.03	.02	-

*$p<.05$

Correlations Between PA and SQ Among Individuals Who Report Any PA

A total of 56.1% respondents reported no vigorous PA, 49.1% respondents reported no moderate PA, 39.6% reported no light PA and 31.8% respondents reported no vigorous and no moderate PA. Since there were higher number of responses reporting no PA within each group, correlations were calculated again after removing participants that reported no PA within each intensity of activity. The relationship between vigorous PA and PSQI was non-significant, indirect, and very weak (r =-.03, p =.82). The relationship between moderate PA and PSQI was non-significant, direct, and very weak (r =.08, p =.51). The relationship between light PA and PSQI was non-significant, direct, and very weak (r =.05, p =.66). The relationship between PA and PSQI was non-significant, direct, and very weak (r =.05, p =.58). Again, no significant correlation was found ($p>.05$; Table 3).

Table 3

Correlations Matrix of Volume of Physical Activity and PSQI Excluding Participants Who Did Not Report Any Vigorous PA, Moderate PA, or Light PA

Variable	1	2	3	4	5
1. Vigorous PA	-				
2. Moderate PA	-.04	-			
3. Light PA	.16	.59	-		
4. Total PA	.67*	.60*	.86*	-	
5. PSQI	-.03	.08	.05	.05	-

*$p<.05$

Difference in SQ Between Those Reporting No PA and Reporting Any PA

To understand the difference in sleep quality between those reporting no PA and those reporting any PA, an independent t-test was conducted. Two groups were created with each intensity of PA variable (vigorous PA, moderate PA, and light PA) with one group including those who reported no PA at that intensity ($MET \cdot min \cdot wk^{-1} = 0$) and the second group including

those who reported any PA at that intensity (MET·min·wk^{-1}> 0). A significant difference in PSQI between groups was found for vigorous PA (t =-2.14, p=.034; Table 4) with those reporting any vigorous PA having lower PSQI score which indicates better sleep quality. Figure 6 shows this difference between groups in a bar graph. There was no significant difference in PSQI scores between groups for moderate PA or light PA (p>.05; Table 4).

Table 4

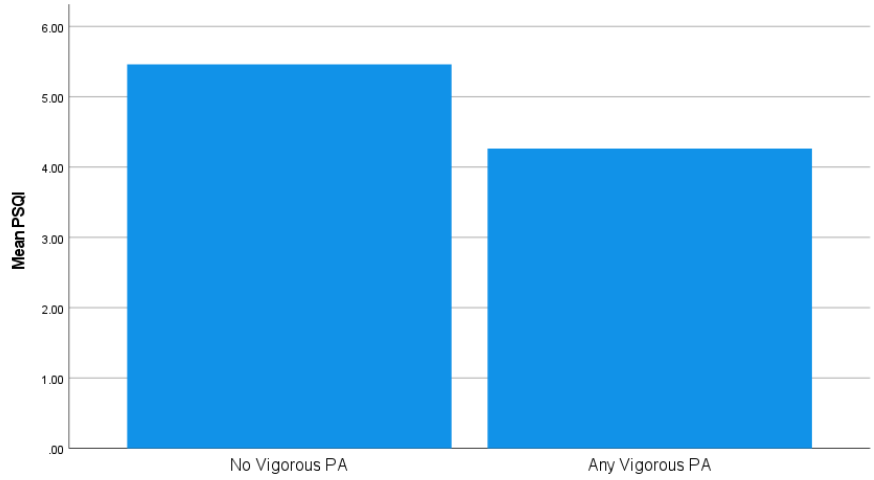
Results of Independent t Test of Difference in SQ by Reported Volume of PA

Variable	MET·min·wk^{-1}= 0		MET·min·wk^{-1}> 0		*t*	*P*	Cohen's *d*
	M	*SD*	*M*	*SD*			
Vigorous PA	5.46	3.14	4.26	2.80	-2.14	.03	-.40
Moderate PA	4.81	3.02	4.97	3.05	.277	.78	.05
Light PA	4.93	2.92	4.89	3.08	-.074	.94	-.01
Total PA	6.00	2.49	4.81	3.08	-.1.41	.24	-.39

*p<.05**.** *Significant difference was found among no vigorous PA and any vigorous PA.*

Figure 6

Bar Graph of Mean PSQI Score for No Vigorous PA and Any Vigorous PA



Differences Between Groups Based on Reported Moderate and Vigorous PA

Further analyses were conducted using four groups created from the vigorous PA and moderate PA variables. The first group consisted of those participants who did not report any vigorous PA (MET·min·wk^{-1}= 0) or any moderate PA (MET·min·wk^{-1}= 0). The second group included individuals who reported any vigorous PA (MET·min·wk^{-1}> 0, but no moderate PA (MET·min·wk^{-1}= 0). The third group included participants who reported any moderate PA (MET·min·wk^{-1}> 0) but no vigorous PA (MET·min·wk^{-1}= 0). The fourth group was those who reported both moderate PA (MET·min·wk^{-1}> 0) and vigorous PA (MET·min·wk^{-1}> 0). A one-way ANOVA was used for analysis. No significance difference was found between the groups (p=.168; Table 5).

Table 5

Results of One-Way ANOVA for Difference in SQ Between Groups of Vigorous and Moderate PA

Variable	*M*	*SD*	*F*	*df*	η^2
No vigorous PA and no moderate PA	5.28	3.08	1.71	3	.04
Vigorous PA and No moderate PA	3.87	2.75			
No vigorous PA and moderate PA	5.64	3.25			
Vigorous PA and moderate PA	4.43	2.85			

Differences Between Groups Created Based on Volume of PA

Within each intensity of PA (vigorous PA and moderate PA), percentile ranges were calculated to create three groups for analysis. The first group included those whose MET·min·wk^{-1}were in the 50th percentile or below. The second group included participants whose MET·min·wk^{-1}were between the 51st and 75th percentiles. The third group was formed by individuals whose MET·min·wk^{-1}were greater than the 75th percentile. Three groups were created for the vigorous PA variable and three different groups were created for the moderate PA variables. Vigorous PA and moderate PA were analyzed separately.

For vigorous PA, the first group was comprised of those who reported 0 MET·min·wk^{-1}. The second group included individuals who reported between 1 and 1,200 MET·min·wk^{-1}, while the third group was made up of those who reported 1,200 MET·min·wk^{-1}or more. A one-way ANOVA was used to analyze group differences. PSQI scores were significantly different between groups for vigorous PA (F = 4.79, p=.01; Table 6). Tukey's post-hoc analyses were conducted to determine which groups were significantly difference from each other and revealed that the groups reporting 0 MET·min·wk^{-1}had significantly higher PSQI scores (poorer sleep quality) than those in the group reporting between 0 and 1,200 MET·min·wk^{-1}(p=.01; Table 7). Although non-significant, there was a trend toward a difference between the group reporting between 0 and 1,200 MET·min·wk^{-1}and those reporting 1,200 MET·min·wk^{-1}or more with the lower volume group having better SQ (Table 7).

For moderate PA, the first group included those reporting 240 MET·min·wk^{-1}or less, while the second group was comprised of those reporting between 241 and 900 MET·min·wk^{-1}. The third group was participants who reported greater than 900 MET·min·wk^{-1}. A one-way

ANOVA was conducted to determine if PSQI was different between the three groups; however, no significant differences were found (p >.05; Table 6).

Table 6

Results of One-Way ANOVA for Difference in SQ of Groups Formed by Percentile Range of Vigorous and Moderate PA

Variable	*0-50th percentile*		*51st -75th percentile*		*>75th percentile*		*F*	*Df*	η^2
	M	*SD*	*M*	*SD*	*M*	*SD*			
Vigorous PA	5.46	3.14	3.30	1.90	5.10	3.21	4.79*	2	.08
Moderate PA	4.82	3.09	4.57	2.70	5.37	3.21	.52	2	

$p<.05$, post hoc test was done for vigorous PA.

Table 7

Post-Hoc Analysis for Vigorous PA Group

Comparison		Mean difference	Standard Error	Df	p_{tukey}
Vigorous PA	Vigorous PA				
1. 0-50th percentile	2	2.14	.70	2	.01
	3	.35	.70	2	.86
2. 51st -75th percentile	1	-2.14	.70	2	.01
	3	-1.78	.81	2	.08
3. > 75th percentile	1	.35	.6	2	.86
	2	1.78	.81	2	.08

Chapter Five: Discussion

The present study aimed to investigate the relationship between sleep quality (SQ) and volume of physical activity (PA) at different intensities among college students. In this online survey, the relationship of SQ was analyzed with vigorous PA, moderate PA, light PA and total PA. Pittsburgh sleep quality index (PSQI) was used to measure SQ and volume of PA was measured in MET·min·wk^{-1}using the International Physical Activity Questionnaire (IPAQ).

Summary of Results

No correlation was found between SQ and vigorous PA, moderate PA, light PA and total PA indicating that there is not a relationship between SQ and volume of PA at any intensity. Even after removing those who reported no PA at each intensity, no significant or meaningful correlations were observed between SQ and volume of PA. Individuals reporting any vigorous PA did have significantly lower PSQI scores (better SQ) than those who reported no vigorous PA. Further, when vigorous PA was divided into three groups based on percentiles, the group reporting a low volume of vigorous PA (between 1 and 1,200 MET·min·wk^{-1}) had significantly better SQ than those reporting no vigorous PA and a trend toward better SQ when compared to higher levels of vigorous PA. No significant differences were observed for moderate PA or when moderate and vigorous PA were combined.

Physically Inactive Participants

A high number of participants reported no PA; 56.1% of responders reported no vigorous PA, 49.1% reported no moderate PA and 39.6% reported no light PA. There were 9% responders who did not report any PA of any intensity. This is expected since according to the literature indicating that half of college students did not meet PA recommendation in the United States

(Choi et al., 2018). This can affect the analysis of data since there is not an equal distribution of scores within each variable and could contribute to the unequal variance between samples.

Relationship Between Volume of PA at Different Intensities and SQ

There was no relationship between SQ and volumes of PA at any intensity or for total PA. The result was different than most of the literature. According to most studies reported in the literature there is a positive correlation between SQ and PA (Badicu, 2018; Choi et al., 2018; Fairbrother et al., 2014; Feng et al., 2014; Hurdiel et al., 2017; Ma et al., 2020; Mahfouz et al., 2020; Stefan et al., 2018; Zhai et al., 2020; Zhai et al., 2021). Among them, there were studies that used the IPAQ to analyze the PA and PSQI to analyze SQ and found positive correlations between SQ and PA. Even though those studies used the same questionnaire to analyze PA and SQ, some studies used different methods than the current study. Choi et al. (2018) conducted a nine-week experimental study of the effects of PA on SQ. In the studies conducted by Badicu (2018) & Feng et al. (2014), investigators provided support to participants when completing the surveys which reduced the chance of errors.

Other studies conducted an online survey which is the same as the current study and found positive correlations between PA and SQ (Zhai et al., 2020, Zhai et al., 2021; Fairbrother et al., 2014). However, their data consist of almost equal distribution of male and female participants unlike the current study which had a high percentage of female participants (71.1%). There might be possibility of influence of other factors like female hormones which can affect the sleep quality of female participants (Pengo et al., 2018). All the mentioned literature did not focus on intensity of PA, but only used total PA for analysis which is also different than the current study. Significant correlations between PA and SQ may have been found in those studies due to high number of responders (>1,000 responders) which can control the danger of reporting

false-negative or false-positive results (Badicu, 2018; Feng et al., 2014; Ma et al., 2020; Mahfouz et al., 2020; Zhai et al., 2020).

On contrary, there were some studies in the literature which found no correlation between PA and SQ similar to the proposed study; however, those studies used different methods and analysis (Fanning et al., 2016; Galas et al., 2021). Fanning et al. (2016) conducted an experimental study in which they used self-regulatory strategies for executive function along with replacement of inactive time by PA. In this unique experimental study, all the participants replaced the inactive time with PA as part of self-regulatory strategies. No significant effect of PA was found on sleep quality among participants. Galas et al. (2021) conducted a survey in which they used IPAQ to analyze PA and Athens Insomnia Scale (AIS) to analyze the relationship between PA and insomnia and they did not find any relationship between PA and insomnia among medical college students. In this study, participants reported poor sleep quality and the relationship between PA and SQ was analyzed on those participants who reported poor sleep quality. Even though they used different methods than the current study they did not find correlations between SQ and PA.

In general, the current literature is divided about the relationship between PA and SQ. Some experimental studies do report a positive effect of PA on SQ (Choi et al., 2018), while some do not (Fanning et al., 2016). Likewise, some studies show a positive relationship between PA and SQ (Fairbrother et al., 2014; Zhai et al., 2020; Zhai et al., 2021); however, one survey and the current study did not find a relationship between PA and SQ (Galas et al., 2021).

Relationship Between Volume of Vigorous Intensity PA and SQ

Despite finding no correlations, SQ was found to be significantly better in those reporting any or low amounts of vigorous PA. This result may contradict available literature. Although no

studies of vigorous intensity exercise could be found, one study did find that increasing the intensity of exercise improved sleep quality. Ezati et al. (2020) conducted an experimental study in which the participants were divided into a control and an exercise group. For the first four-week, exercise was performed at 45-50% of maximum heart rate (very light intensity), then the intensity was increased to 65-70% of maximum heart rate (moderate intensity) during the second four-week period. Sleep quality did not change in the control group. Much like the current study, sleep quality improved more during the second four-week period which was at a higher intensity. Although, the intensity in the Ezati et al. (2020) study did not reach vigorous intensity, it may indicate that increasing the intensity of exercise results in a greater improvement in SQ supporting the results of the current study.

Limitations

This study has several limitations. Firstly, a self-administrated survey was used to collect data. The volume of PA was calculated based on the response. Four outliers were removed from the study because those responders reported higher levels of PA than they could actually perform. Secondly, the number of complete responses were low because several participants did not complete the sleep quality questions. The survey used the validated IPAQ and PSQI questions which may be too long for participants to read and answer on a mobile device. Thirdly, range restriction may be making it difficult to find correlations. The data lacks range in each of the PA variables because so many participants reported no PA within each PA variable. Range restriction may also be presented in the PSQI variable.

Future Studies

This study can be useful to understand the relationship of SQ with the volume of PA at different intensities. It may indicate the importance of vigorous intensity PA in improving sleep

quality which is different than previous studies and suggests the need for further study. In order to improve sleep quality, college students may choose to perform low volumes of vigorous PA. Future studies should be done with a larger sample size focused only on vigorous PA to analyze the relationship between vigorous PA and SQ in detail. An experimental study should be designed to determine if sleep quality is improved more at higher intensities of physical activity.

Conclusion

This study concluded that there is no relationship between sleep quality and volume of physical activity at any intensity among college students; however, college students reporting lower amounts of vigorous activity reported better sleep quality as compared to vigorously inactive college students.

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Appendix A

International Physical Activity Questionnaire

(IPAQ)

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

Appendix B

Pittsburgh Sleep Quality Index

(PSQI)

Name_____ Date_____

Sleep Quality Assessment (PSQI)

What is PSQI, and what is it measuring?

The Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven areas (components): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month.

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month,

1. When have you usually gone to bed? _____
2. How long (in minutes) has it taken you to fall asleep each night? _____
3. What time have you usually gotten up in the morning? _____
4. A. How many hours of actual sleep did you get at night? _____
   B. How many hours were you in bed? _____

5. During the past month, how often have you had trouble sleeping because you	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
A. Cannot get to sleep within 30 minutes				
B. Wake up in the middle of the night or early morning				
C. Have to get up to use the bathroom				
D. Cannot breathe comfortably				
E. Cough or snore loudly				
F. Feel too cold				
G. Feel too hot				
H. Have bad dreams				
I. Have pain				
J. Other reason (s), please describe, including how often you have had trouble sleeping because of this reason (s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
9. During the past month, how would you rate your sleep quality overall?	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)

Scoring

Component 1	#9 Score	C1 _____
Component 2	#2 Score (<15min (0), 16-30min (1), 31-60 min (2), >60min (3)) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)	C2 _____
Component 3	#4 Score (>7(0), 6-7 (1), 5-6 (2), <5 (3)	C3 _____
Component 4	(total # of hours asleep) / (total # of hours in bed) x 100 >85%=0, 75%-84%=!, 65%-74%=2, <65%=3	C4 _____
Component 5	# sum of scores 5b to 5j (0=0; 1-9=1; 10-18=2; 19-27=3)	C5 _____
Component 6	#6 Score	C6 _____
Component 7	#7 Score + #8 score (0=0; 1-2=1; 3-4=2; 5-6=3)	C7 _____

Add the seven component scores together _____ *Global PSQI* _____

A total score of "5" or greater is indicative of poor sleep quality.
If you scored "5" or more it is suggested that you discuss your sleep habits with a healthcare provider