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Relationship between Physical Activity and Sleep Quality with Muscle Mass in Female Medical Students

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Abstract

Female medical students tend to have low physical activity levels (PAL) accompanied by a poor sleep quality. This condition could disrupt muscle protein metabolism, resulting in decreased muscle mass at a young age. This study aimed to determine the association between physical activity and sleep quality with muscle mass in female medical students. A cross-sectional study design was conducted on 60 female students according to the criteria selected using stratified random sampling. The study instruments were Tanita Medical Body Composition Analyzer (MC-980MA Plus), Global Physical Activity Questionnaire (GPAQ), and Pittsburgh Sleep Quality Index (PSQI). Study results found that 34 (56,7%) subjects, 23 (38,3%) subjects, and 3 (5%) subjects had low, normal, and high muscle mass respectively. Physical activity levels (PAL) of 25 (41,7%) subjects were low, 30 (50%) subjects were moderate, and 5 (8,3%) subjects were high. A number of 55 (88,3%) subjects had a poor sleep quality, while the other 7 (11,7%) subjects had a good sleep quality. Multiple regression logistic test showed that PAL had more effects on muscle mass (p = 0,000; OR = 14,056, CI = 3,488-56,637) compared to sleep quality (p = 0,104; OR = 7,680, CI = 0,657-89,726). Therefore, young adults need to exercise regularly and perform sleep hygiene to maintain their muscle mass.

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INTRODUCTION

Skeletal muscles play a crucial role in supporting strength, physical functions, and metabolic regulations of the body, primarily needed by athletes to enhance their performance (Devries & Phillips, 2015). Not only athletes, every individual needs muscle mass and strength to live independently and to enhance a defense against various diseases (McGlory et al., 2019). With an advancing age, there is a decline in muscle mass and strength known as sarcopenia. This condition commonly occurs in the elderly, making them vulnerable to weakness, disability, and even death (Cao & Morley, 2016).

Muscle mass metabolism is greatly influenced by the balance between protein synthesis and degradation, which depends on the nutrition intake especially protein, physical activity, hormonal balance, and diseases (Frontera & Ochala, 2015). Another factor that can affect muscle mass is gender, with males tending to have a higher skeletal muscle mass compared to females (Bredella, 2017). Lifestyle factors, such as alcohol consumptions, smoking, and high-stress levels, also contribute to the inhibition of muscle protein synthesis, negatively affecting the muscle mass (Marzetti et al., 2017).

A study in Korea found that muscle mass insufficiency had been already present in young and middle-aged women, including college students (Kim et al., 2018). Female medical students are vulnerable due to their busy academic schedules, resulting in the less time for physical activity (Al-Asousi & El-Sabban, 2016). Research results showed that the majority of female medical students had low physical activity levels (Annamayra et al., 2022). Physical activity is actually one stimuli of the anabolic hormones, namely growth hormone (GH), insulin-like growth factor 1 (IGF-1), testosterone, and estrogen (Distefano & Goodpaster, 2018; Gharahdaghi et al., 2021).

In addition to directly affecting muscle mass formation, physical activity can also inhibit the decline of muscle mass by increasing the muscle capillarity, mitochondrial functions, muscle cell count, insulin sensitivity and reducing proinflammatory cytokines (Suhada et al., 2021). The benefits of physical activity for muscle mass can be obtained through a resistance training and aerobic exercises (Distefano & Goodpaster, 2018).

Another impact of the busy schedules of female medical students is the need for longer study hours, which can affect their sleep quality. Research results on medical students, mostly females, found that 81.2% of the subjects had a poor sleep quality (Nurrahman, 2023). A poor sleep quality can be problematic because sleep plays a crucial role in regulating endocrine functions, including the muscle tissue regeneration and remodeling (Buchmann et al., 2016). Individuals with sleep disturbances show imbalances in anabolic and catabolic hormones of muscle proteins (Stich et al., 2022). The secretion of anabolic hormones GH, IGF-1, and testosterone decreases, resulting in the decreased muscle protein synthesis. Conversely, there is an increase in the catabolic hormone cortisol, which stimulates protein degradations and myostatin expressions, negatively affecting skeletal muscles (Amanah & Citrawati, 2020).

Several studies on muscle mass had been conducted, but they only focused on one factor, physical activity or sleep quality. Moreover, few studies still discuss the relationship between physical activity, sleep quality, and muscle mass in young subjects. Based on this rationale, this research was conducted to determine the relationship among physical activity, sleep quality, and muscle mass in female medical students.

METHODS

This research is a quantitative cross-sectional study conducted in October 2023 at the Physiology and Nutrition Laboratory Unit of the Medical Education Research Center, Universitas Pembangunan Nasional "Veteran" Jakarta.

Participants

The research subjects were female students of the Faculty of Medicine Universitas Pembangunan Nasional "Veteran" Jakarta (FM UPNVJ), Academic Year 2023/2024, who met the criteria. The inclusion criteria were female students aged at least 18 years with a mild or moderate stress levels and sufficient protein intake. Students who were taking medications affecting the muscle mass and sleep quality, consuming coffee daily for the past month, consuming alcohol, smoking, having a history of or currently experiencing sleep distrbances, and experiencing musculoskeletal disorders and respiratory disorders were excluded from the study.

The sampling was administered using a stratified random sampling technique. The sample size calculation used the hypothesis testing formula for the difference in proportions. The minimal sample size for this study was 60 subjects.

Instruments

The instruments used in this study were the Tanita Medical Body Composition Analyzer (MC-980MA Plus), Global Physical Activity Questionnaire (GPAQ), and Pittsburgh Sleep Quality Index (PSQI). The Tanita Medical Body Composition Analyzer is a tool for measuring and analyzing body compositions, including muscle mass assessed based on the total weight of skeletal muscles, smooth muscles, and water contained in muscles. This instrument has a sensitivity of 77% and specificity of 71% in measuring muscle mass (Reiss et al., 2016). Muscle mass is presented in the form of scores, where scores -4 to -2 indicate a low muscle mass, scores -1 to +1 indicate a normal muscle mass, and scores +2 to +4 indicate a high muscle mass (Tanita, 2021).

GPAQ is a questionnaire assessing physical activity in the age group of 16-84 years in developing countries, proven to be valid and reliable (Fazriani, 2023; Pratiwi, 2019). GPAQ assesses physical activity at work, during travel, recreation, and sedentary activities. Total physical activity is presented in metabolic equivalent of task (MET) units with interpretations of light (MET < 600), moderate (600 < MET < 3000), and heavy MET > 3000) physical activity (Fazriani, 2023; Pratiwi, 2019).

The sleep quality was assessed using the PSQI questionnaire for the past month. This questionnaire has a validity of 0.365 – 0.733 and reliability of 0.741, making it sufficiently valid and reliable for assessing the sleep quality (Ratnasari, 2016). The PSQI questionnaire consists of 7 components, namely subjective sleep quality, sleep latency, sleep duration, sleep disturbances, sleep efficiency, use of sleep medication, and daytime dysfunctions (Lohitashwa et al., 2015). The assessment results of these components are summed up, with a total score <5 indicating a good sleep quality and >5 indicating a poor sleep quality (Haryati et al., 2020).

Procedure

This study was approved by the Health Research Ethics Committee of Universitas Pembangunan Nasional "Veteran" Jakarta with ethical clearance number 363/IX/2023/KEP. Subsequently, the researchers distributed the initial questionnaire via Google form to select potential research subjects. Subjects who met the research criteria were asked to come to the laboratory to undergo the research procedure.

Subjects first filled out the GPAQ and PSQI questionnaires. After that, the body composition was examined using Tanita Medical Body Composition Analyzer (MC980MA Plus). The procedure for using the device began with the examiner entering the research subject identity into the device, including name, ID number, date of birth, gender, and height. Subsequently, research subjects were asked to remove objects that could affect the assessment, such as jewelry or metal objects, before standing on the examination device without footwear. Both feet stepped on two electrodes, and both hands grasped two other electrodes. These four electrodes sent safe low electrical signals throughout the subject body. The subjects maintained the standing position for 30 seconds.

The data analysis consisted of univariate analysis to obtain the subject physical activity, sleep quality, and muscle mass descriptions, followed by bivariate analysis using Chi-square or Fisher's exact test and multivariate analysis with multiple logistic regression test to test hypotheses.

RESULT

The median age of the research subjects was 19.5-20 years, with the majority having moderate stress levels and all having a sufficient protein intake. There were no differences in age, stress, and protein intake between the low muscle mass group and the normal+high muscle mass group ($p > 0.05$) (Table 1). It showed that age, stress level, and protein intake were not confounding factors influencing muscle mass in this study.

Table 2 shows that the majority of the subjects had a moderate physical activity (50%), a poor sleep quality (88.3%), and a low muscle mass (56.7%). The Chi-square test results showed a significant relationship between physical activity and muscle mass. Subjects with a low physical activity level were 14 times more likely to have a low muscle mass (Table 3).

Table 1. Characteristics of Research Subjects

Characte-ristics	Low Muscle Mass	Normal + High Muscle Mass	p-value
Age,			
median	20	19.5	0.531[a]
(min - max)	(18-22)	(18-21)	
Stress Level, n (%)			
Mild	8 (72.7)	3 (27.3)	0.320[b]
Moderate	26 (53.1)	23 (46.9)	
Protein Intake			
(mean + SD)	50.45 + 7.9	50.70 + 7.8	0.806a

Note: aMann-Whitney Test bFisher's Exact Test

Table 2. Physical Activity, Sleep Quality, and Muscle Mass

Characteristics	Frequency (n)	Percentage (%)
Physical Activity		
Mild	25	41.7
Moderate	30	50
Heavy	5	8.3
Sleep Quality		
Poor	53	88.3
Good	7	11.7
Muscle Mass		
Low	34	56.7
Normal	23	38.3
High	3	5

Table 3. The Relationship between Physical Activity and Muscle Mass

Variable	Muscle Mass				Total		OR (95% CI)	p-value
	Low		Normal+High					
	n	%	n	%	n	%		
Physical Activity								
Mild	22	88	3	12	25	100	14.056	0.000
Moderate+Heavy	12	34.3	23	65.7	35	100	(3.488-56.637)	

Table 4. The Relationship between Sleep Quality and Muscle Mass

Variable	Muscle Mass				Total		OR (95% CI)	p-value
	Low		Normal+High					
	n	%	n	%	n	%		
Sleep Quality								
Poor	33	62.3	20	37.7	54	100	9.900	0.036
Good	1	14.3	6	85.7	7	100	(1.109-88.339)	

Table 5. The Initial Model of Logistic Regression

Variable	p-value	OR	95% CI
Physical Activity	0.000	12.892	3.068-54.180
Sleep Quality	0.104	7.680	0.657-89.726

Table 6. The Final Model of Multiple Logistic Regression

Variable	p-value	OR	95% CI
Physical Activity	0.000	14.056	3.488-56637

The Fisher's exact test results showed a significant relationship between sleep quality and muscle mass. Subjects with a poor sleep quality were 9 times more likely to have a low muscle mass (Table 4).

In the initial multivariate analysis model, the sleep quality variable had a p-value = 0.104 (Table 5), thus this variable was excluded from the study. To ensure that the sleep quality variable was not a confounding variable, an assessment of the change in OR was performed on the physical activity variable. The result showed a 9.02% change in OR, indicating that the sleep quality variable was not considered a confounding variable and could be excluded from the model.

The final model of the multiple logistic regression analysis proved that physical activity was the variable influencing the muscle mass with OR = 14.056 (Table 6).

DISCUSSION

Age is one of the factors influencing muscle mass. The quantity and quality of muscle mass decrease with age, marked by a decrease in muscle and muscle capacity to perform its functions (Distefano & Goodpaster, 2018; Fragala et al., 2015; Limpawattana et al., 2015). The decrease in muscle mass starts at the age of 30 and increases after the age of 60. This is supported by longitudinal studies showing significant declines in muscle mass in the elderly (75 year old) with a rate of decline in women of 0.64-0.7% per year (Wilkinson et al., 2018). The results of this study showed no difference in age between muscle mass groups (p = 0.531) (Table 1), so the age variable did not affect the difference in the muscle mass found in the study.

This study selected the research subjects with a mild to moderate stress level. It was conducted to control the stress level variable, which could affect the hormone balance indirectly affecting the muscle mass. The higher the stress level, the higher the cortisol level (Walvekar et al., 2015). As a muscle catabolic hormone, increased cortisol will also affect the muscle mass metabolism by increasing the rate of muscle degradation and interfering with mitochondrial functions to meet the needs of muscle metabolism processes (Stefanaki et al., 2018). The results of this study showed no difference in stress levels between muscle mass groups (p = 0.320), hence the stress level variable did not affect the difference in the muscle mass found in this study.

In addition to age and stress level, the subject protein intake was also a controlled factor in this study. Protein intake was calculated based on the formula for protein requirement of 0.8 (g) x body weight (kg). Protein intake is considered sufficient if the result is 0.8 – 1 g/kgBW (Setiowati, 2014). Adequate protein intake is crucial in muscle formations considering its role of 20% in muscle building (Frontera & Ochala, 2015). The specific protein intake needed is Branched Chain Amino Acid (BCAA) in the form of essential amino acids leucine, isoleucine, and valine, which are abundant in animal protein sources. Previous studies had shown a positive correlation between protein intake and muscle mass. A high protein intake increased the muscle mass, while an inadequate protein intake decreased the muscle mass (Fath, 2021). No differences were found in protein intake between muscle mass groups (p = 0.806) in this study, so the protein intake variable did not affect the study results.

The majority (50%) of the research subjects had a poor sleep quality. This result is consistent with research results on female students in Japan and at the Faculty of Medicine, Mataram University, where the majority of the samples had moderate physical activity levels (Aritonang et al., 2022; Oshita & Myotsuzono, 2021). This moderate level of physical activity aligns with WHO recommendations for engaging in a moderate-intensity physical activity for 150 minutes/week or 30 minutes/day (WHO, 2020).

In this study, the majority (88.3%) of the research subjects had a poor sleep quality. Similar results were found in a study on medical students at Udayana University, where the majority of subjects also had a poor sleep quality (Bianca et al., 2021). One of the factors that can affect the sleep quality is sleep hygiene, including behaviors performed before or during bedtime to improve the sleep quality and duration. This includes maintaining a sleep duration of 7-9 hours, consistent sleep and wake patterns, taking a 20-30 minute nap, avoiding naps in the evening, avoiding caffeine consumption before bedtime, limiting alcohol, avoiding eating 2 hours before bedtime, maintaining a dark, quiet, and peaceful sleep environment, and avoiding bright lights and electronics before bedtime (Baranwal et al., 2023; Grummon et al., 2021; Mantua & Spencer, 2017; Potter et al., 2016; Watson et al., 2015). A poor sleep quality can disrupt the body homeostasis in metabolic tissues, such as adipose tissue, liver and skeletal muscles (Lamon et al., 2021). Therefore, it is important for individuals to maintain a good sleep quality by adopting sleep hygiene behaviors.

Muscle mass in this study was presented in the form of scores from -4 to +4, indicating that the higher the score, the more the muscle mass, and vice versa (Marthoenis et al., 2022). The majority (56.7%) of the research subjects had a low muscle mass. This result could be influenced by the level of physical activity of the subjects. Types of physical activity such as resistance training like weightlifting, plank, sit-up squat, and push-up have been shown to be beneficial in increasing the muscle mass. For this reason, it is important for research subjects to schedule regular resistance training sessions for a minimum of 8 weeks to achieve significant changes in the muscle mass (Krzysztofik et al., 2019).

The Chi-square test results showed a significant relationship between physical activity and muscle mass (p = 0.000; OR = 14.056), with individuals with low physical activity levels being 14 times more likely to have a low muscle mass. Oshita & Myotsuzono study yielded similar results using the Dietary Reference Intakes for Japanese (DRIs-J) instrument to assess physical activity and Bioimpedance Instrument Analysis (BIA) to measure muscle mass (Oshita & Myotsuzono, 2021). The mechanism mediating the relationship between physical activity and muscle mass involves increased secretion of anabolic hormones GH, IGF-1, testosterone, and estrogen, which stimulate the rate of muscle protein synthesis to form muscle mass (Gharahdaghi et al., 2021). On the other hand, physical activity can also decrease proinflammatory cytokines and increase muscle cell components such as satellite cells for proliferation and differentiation of new muscle fibers, which function to inhibit the decline in muscle mass (Sayisvir, 2019).

Fisher's exact test results showed a relationship between sleep quality and muscle mass (p = 0.036; OR = 9.900), with individuals with a poor sleep quality being 9 times more likely to have a low muscle mass. Previous research by Locquet et al., 2018 examining the relationship between sleep quality and sarcopenia index found similar results, with individuals with sarcopenia having higher PSQI scores on several components compared to healthy individuals. This relationship is mediated by hormone secretion patterns and immune responses (Song et al., 2023). An inadequate sleep duration results in the inhibition of the secretion of anabolic hormone IGF-1 and testosterone while increasing the secretion of the muscle protein catabolic hormone cortisol (Yoshida & Delafontaine, 2020). A poor sleep quality also leads to increased proinflammatory cytokines IL-6 and TNF-alpha, which can disrupt the muscle regeneration and growth (Song et al., 2023).

The multiple logistic regression analysis results showed that physical activity was the most influential variable on muscle mass (p = 0.000; OR = 14.056; CI = 3.488-56.637) compared to sleep quality (p = 0.104; OR = 7.680; CI = 0.657-89.726). Physical activity acts as the primary anabolic stimulus for muscle mass. Previous studies had shown a significant increase in protein synthesis rate exceeding its degradation rate immediately after physical activity, resulting in an increase in overall body protein as the raw material for tissue formations, including muscle tissues. Other experiments had also shown an increase in protein synthesis rate exceeding its degradation rate for up to 48 hours after a resistance training (McGlory et al., 2019).

Limitations of this study include the inability to generalize the results to all genders because it was only conducted on female subjects. Therefore, it is recommended that the future research conduct a study on both young male and female subjects accompanied by measurements of GH, IGF-1, estrogen, and cortisol levels to explain the roles of these hormones in mediating the relationship between physical activity and sleep quality with muscle mass.

CONCLUSION

Based on the data and analysis of the research results, it concludes that physical activity has the greatest influence on muscle mass compared to sleep quality. Therefore, it is recommended that young adults engage in a regular physical exercise, especially the resistance training, and implement sleep hygiene behaviors to increase and maintain their muscle mass.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

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