JSSF 10 (2) (2024)

Journal of Sport Sciences and Fitness

http://journal.unnes.ac.id/sju/index.php/jssf

Correlation Of Nutritional Status, Physical Activity, Protein, and Magnesium Intake with Muscle Endurance Among College Students

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Article Info

Article History:

Received December 2024

Approved December 2024

Published January 2025

Keywords:

Physical Activity, Magnesium Intake, Protein Intake, Muscle Endurance, Nutritional Status

Abstract

Muscular endurance is included in the components of fitness related to health. Good muscular endurance is important for college students to reduce muscle fatigue so they can do activities including studying longer. The purpose of this study was to analyze the correlation between nutritional status, protein intake, magnesium, and physical activity with muscle endurance. This study is a quantitative study using a cross-sectional design. The sampling technique used was purposive sampling concerning predetermined criteria and a sample of 99 students in Jakarta was obtained. The instruments in this study used a weighed food record, a physical activity recall form, and a push-up and wall squat muscle endurance test form. The Pearson and Spearman correlation tests analyzed the relationship between independent and dependent variables. Most of the respondents had poor and very poor muscle endurance both based on push-ups (96%) and wall squat tests (79,8%). The majority of respondents had good nutritional status (57.6%), insufficient protein intake (56.6%), insufficient magnesium intake (98%), and light physical activity level (93.9%). Nutritional status, protein intake, magnesium, and physical activity were not significantly correlated with muscle endurance in college students (p-value> 0.05).

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ISSN 2252-6528

INTRODUCTION

Muscle endurance is the ability of skeletal muscle groups to do repeated contractions against load over time. Individuals with high muscle endurance can carry out activities for longer continuously, thus delaying the onset of fatigue. Good muscle endurance is important for college students to build greater resistance to muscle fatigue so they can study and be active for a longer period (Utari, 2007). Not only athletes but college students also need good muscle endurance, for example, to deal with the full lecture schedule, traffic jams, and using public transportation, which requires standing for a long time. Poor muscle endurance will make them often feel physically tired and sore which can make them lack focus and reduce productivity. However, the muscular fitness of college students based on previous studies was still problematic. Almost half of college students had poor hand grip strength (Fitriani & Purwaningtyas, 2020).

Achieving a good level of muscle endurance requires optimal nutritional status, physical activity, and training including physical fitness, especially muscle endurance, as well as the availability and intake of nutritious food. The overweight and obese prevalence among 20-24-year-olds was 22% (Ministry of Health, 2023). The overweight and obese college students tend to have higher body fat and low muscle mass. It can be a barrier to having good muscle endurance. A previous study showed that the percentage of body fat and muscle mass had a significant correlation with muscle endurance in young taekwondo athletes (Purwaningtyas et al., 2021). There is limited study that analyzed the correlation between nutritional status with muscle endurance among non-athlete college students in Indonesia.

The other problem is the lack of physical activity carried out by college students due to lecture schedules and assignments. Nationally, 40% of the population aged 20-24 years lack of physical activity. Respondents with a lack of physical activity are at 10 times greater risk of experiencing poor physical fitness (Setiawan *et al.*, 2021).

The optimal physical condition will not be achieved if it is not supported by adequate nutritional intake. Fulfillment of nutritional needs is important to maintain or increase muscle endurance in students. Protein and magnesium are nutrients that play a key role in muscle function (Souza *et al.*, 2023).

This study has several novelties. Many previous studies have only looked at total protein intake. In this study, protein intake was seen from the amount of animal protein and the amount of vegetable protein. In addition, research related to magnesium intake with muscle endurance is still rare and only exists in athletes. In this study, protein and magnesium intake were assessed by weighing food records which is still limited in previous studies. So, this study is important to analyze the correlation between nutritional status, physical activity, protein, and magnesium intake with muscle endurance among college students.

METHOD

This research is classified as an observational quantitative study using a cross-sectional method. It was conducted in Jakarta. The population in this study was college students in Jakarta. The 99 respondents aged 19-23 years old were obtained through purposive sampling.

The inclusion criteria include student college aged 17-25 years old; living in Jakarta, Bogor, Depok, Tangerang, or Bekasi (Jabodetabek) area; and passing the PAR-Q and You screening test. Before data collection, respondents were initially screened with PAR-Q and YOU, which contained 10 questions. If there was 1 answer "yes", then the student could not be a respondent, because it was recommended to consult a doctor before taking a physical fitness test. Meanwhile, the exclusion criteria include having a serious illness and taking special diet programs like low-energy, vegetarian, and ketogenic diets.

Data collection included interviews using questionnaires, self-filling of weighed food record questionnaires, and muscle endurance measurement tests through push-ups and wall squats. Protein and magnesium intake data were obtained from the weighed food record questionnaire 2 x 24 hours non-consecutive, entered into the Nutrisurvey, then the average protein and magnesium intake was obtained, which was then divided by the calculation of the needs according to the individual nutritional needs of the students. The results of the percentage of protein and magnesium intake levels were then categorized into less (<90%), sufficient (90-119%) and more (> 120%) (Hardinsyah et al, 2012). Based on protein recommendations according to balanced nutrition guidelines, the need for animal and vegetable protein is 2-4 servings, namely 28 g of animal protein, while vegetable protein needs 20 g.

The percentage of adequacy is calculated by dividing the average number of g of animal or vegetable protein intake consumed by the needs based on balanced nutrition guidelines then multiplied by 100. The cut-off points for the proportion of animal protein intake to total protein are based on the mean value. It's categorized as low <61.6 g and high >61.7 g. While for the proportion of vegetable protein intake to total protein based on the mean value, is low if <38.1 and high> 38.2. Magnesium intake is categorized as lacking <77% RDA and sufficient if> 77% RDA (Gibson, 2005).

The results of weight and height measurements are plotted to the Body Mass Index (BMI). It is categorized into undernutrition (<18.5), good nutrition (>18.5 - 24.9), overnutrition (>25.0 - 27.0), and obesity (>27.0) (Ministry of Health, 2013). Physical activity is categorized as light if (>1.40 -1.69), moderate if (>1.70 - 1.99), and heavy if (>2.00 - 2.40) (FAO/WHO/UNU, 2001).

A push-up test was used to assess upper extremity muscle endurance while a wall squat assessed lower extremity muscle endurance. Push-up was done by measuring how many times the respondent can do push-ups correctly. The respondent lies face down on a flat surface. Both hands are opened shoulder-width apart (for women, the knees are bent or attached to the floor). Lower the body so that the elbows form a 90-degree angle. Lift the body and lower the body until it almost touches the floor. The movement is carried out continuously without rest. Push-up endurance is said to be very good if the respondent can do push-ups>54 repetitions for men and >48 repetitions for women, good 45-54 repetitions for men and 34-48 repetitions for women, sufficient 35-44 repetitions for men and 17-33 repetitions for women, poor 20-34 repetitions for men and 6-16 repetitions for women, very poor <20 repetitions

for men and <6 repetitions for women (Mackenzie, 2005).

Wall squat endurance by measuring the duration of how long respondents can persist in doing the correct movement. The respondent's position is sitting with their backs against the wall. Feet flat on the base (mat/floor) forming a 90-degree angle at the hips and knees. The officer gives the command "yes" and the stopwatch starts. The movement is done as hard as possible without rest. Wall squat endurance is said to be very good if respondents can do wall squats >102 seconds for male and female respondents >60 seconds, categorized as good if they can do wall squats 102-76 seconds for male and female respondents 60-46 seconds, sufficient 75-58 seconds for male and female respondents 45-36 seconds, less 57-30 seconds for male and female respondents 35-20 seconds, poor <30 seconds for male and female respondents <20 seconds (Mackenzie, 2005).

The data results were analyzed using a correlation test to analyze the relationship between nutritional status based on BMI, protein intake, magnesium, and physical activity with muscle endurance through push-ups and wall squats. If the data is normally distributed, use Pearson correlation and if the data is not normally distributed, use Spearman.

RESULTS AND DISCUSSION

1. Research Results

Table 1 shows that the majority of respondents are female. The youngest respondent is 19 years old and the oldest is 23 years old, most respondents are in range 19-21 years old.

Table 1. Individual Characteristics

Characteristics	n	%
Sex		
Male	9	9.1
Female	90	90.9
Age		
19-21 years	67	67.6
22-23 years	32	32.4

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Table 2. Distribution of muscle endurance nutritional status, protein adequacy, magnesium adequacy, and physical activity

Variable	n	%	Median (Min-Max) Mean ± SD
Push-up			
Fair	4	4.0	9.00 (2-20)
Poor	59	59.6	times
Very Poor	36	36.4	
Wall Squat			
Good	6	6.1	28.07 ± 9.82
Fair	14	14.1	seconds
Poor	49	49.5	
Very Poor	30	30.3	
Nutritional Status			
Obesity	16	16.2	22.88 ± 4.56
Overweight	11	11.1	kg/m^2
Good Nutrition	57	57.6	
Under Nutrition	15	15.2	
Total Protein Adequacy			
More	15	15.2	89.51 ±
Enough	28	28.3	32.75%
Less	56	56.6	
Proportion of Animal Protein Intake to Total Protein			
High	53	53.5	61.74 ± 11.93
Low	46	46.5	g
Proportion of Plant Protein Intake to Total Protein			
High	46	46.5	38.25 ± 11.93
Low	53	53.5	g
Magnesium Adequacy			
Enough	2	2	29.39 (4.0-
Less	97	98	289.1) %
Physical Activity			
Moderate	6	6.1	1.53 (1.40-
Light	93	93.9	1.97) PAL

Based on Table 2, most of the respondents had poor and very poor muscle endurance both based on push-ups (96%) and wall squat test (79,8%). Meanwhile, based on the wall squat test, is dominated by respondents with leg muscle endurance in the poor category

(49.5%). More than half of the respondents (57.6%) have good nutritional status. More than half of the respondents (56.6%) had inadequate protein intake. Based on the source of protein, the proportion of animal protein intake to total protein is relatively high (53.3% of respondents). The proportion of plant protein intake to total protein is relatively low (53.5% of respondents). Most of the respondents (98%) lack of magnesium intake. The proportion of physical activity of 93.9% of respondents was still in the light category.

Table 3. Correlation Test of Factors Related to Muscle Endurance

Variable	*Push-Up*		*Wall Squat*	
	R	**P**	**R**	**P**
Nutritional Status	-0.143	0.158	-0.166	0.101
Protein Intake	0.054	0.593	0.009	0.930
Magnesium Intake	0.007	0.942	0.013	0.895
Physical Activity	0.107	0.294	0.091	0.373

*: Test of significant relationship

Table 3 showed that nutritional status, protein intake, magnesium intake, and physical activity were not significantly correlated with arm and leg muscle endurance as measured by push-up and wall squat.

2. Discussion

High muscle endurance can be obtained with sufficient exercise and adequate nutrient intake. The fulfillment of nutrient intake is important for maintaining and increasing muscle endurance. In addition, sufficient levels of physical activity and good nutritional status can also optimize the potential for muscle endurance.

The majority of respondents had normal nutritional status. This result is in line with previous study that stated most of urban young age had normal nutritional status Fitriani & Purwaningtyas, 2020).

However, the muscle endurance of the majority of respondents was classified as poor and very poor, both arm muscle endurance measured through the push-up test and leg muscle endurance measured through the wall squat test. The results of this study stated that the average muscle endurance of respondents measured through push-ups had a value of 9 reps, while the average duration of wall squat was 28 seconds. In line with the results of the study by Fildania and Jayadi (2022) using an arm muscle power test through push-ups which showed that the majority of respondents, as many as 73%, had a poor push-up quality level (Fildania & Jayadi, 2022). A systematic review in Brazil showed the relevant result, less than half of children and adolescents in Brazil had good muscle endurance (da-Silva-Junior et al., 2022).

These results also align with Irdilla's research, which stated that there was no significant relationship between nutritional status and muscle endurance, $p = 0.095$ (Irdilla et al., 2016). Nutritional status, as seen from BMI or BMI for age, isn't enough to predict muscle endurance. Body composition, like the percentage of total body fat and muscle mass, correlated more significantly with muscle endurance (Purwaningtyas et al., 2021). Other factors that can also affect muscle endurance include exercise. If someone with good nutritional status does not do enough physical activity or does not do regular physical exercise, their fitness level, including muscle endurance, is not necessarily good. The volume and frequency of exercise significantly affect muscle endurance because it can increase muscle fiber

synthesis. The more muscle fibers, the easier it will be to get a sufficient oxygen supply when doing exercises that require muscle endurance such as push-ups and wall squats (Tangkudung, 2021).

Respondents had an average protein intake of 53.4 g/day categorized as insufficient protein intake. Information obtained in the field showed that there was an irregular eating pattern, related to the amount, type, and portion of food that is not good and the lack of modification of food sources of protein. The animal protein intake was higher than the plant protein intake. Respondents consumed plant protein which is only obtained from tofu and tempeh. The consumption of animal protein comes from high-calorie and high-fat foods. The most consumed animal protein was fried chicken.

Protein intake didn't correlate significantly with muscle endurance through push-ups and wall squats. This is in line with a study conducted by Rabiah et al (2022), that there was no significant correlation between protein intake and fitness levels with a p-value of 0.345 (Rabiah et al., 2022).

Protein doesn't have a primary function directly in providing energy for someone exercising. Protein plays a role in the formation and repair of damaged tissues and as an energy reserve when carbohydrate reserves are depleted and fat oxidation as an energy source is limited (Gropper et al., 2020). Protein has a crucial role in increasing muscle mass. Adequate muscle mass is a primary source for developing muscle endurance. However, adequate protein intake must be accompanied by proper exercise to increase muscle mass and endurance. If protein consumption is not accompanied by exercise and adequate energy consumption, it will not increase the desired muscle endurance performance (Islamiyati et al., 2020).

The average magnesium intake of respondents was 105.7 mg/day, categorized as inadequate intake. Several respondents had sufficient magnesium intake, but muscle endurance, both push-ups and wall squats, were included in the poor category. Almost all respondents rarely consume foods that are sources of magnesium. Magnesium is present in a diverse range of foods. Notably, foods such as nuts, seeds, and wholegrain cereals are especially rich in magnesium. The magnesium-rich food that is rarely consumed such as dark chocolate, nuts, avocados, almonds, cashews, peas, soybeans, wheat, oats, tofu, bananas, green vegetables, and seeds, namely flax seeds, pumpkin, and chia (Gropper et al., 2020). Respondents are not interested in consuming foods that are sources of magnesium. They more often eat processed foods that suit their tastes and do not pay attention to the nutritional value of the food they consume. Food processing, such as refining whole wheat by removing the germ and outer bran layers, significantly reduces its magnesium content by more than 75%.

The results of the bivariate test showed that there was no significant correlation between magnesium intake and muscle endurance. This result is in line with research conducted by Amin et al. (2017), which stated that there was no significant relationship between magnesium intake and muscle endurance. Other factors influence it, namely inhibitory substances for magnesium absorption, such as phytic acid in cereals and nuts and oxalate in vegetables (Rosvita et al., 2018).

The results of 2 x 24-hour interviews of respondents who spent most of their time in class to take courses and the habits of respondents who tend not to do heavy physical activity during their free time, because after returning from college, most respondents often play with cellphones, computers or watch television, so that sedentary activities or less activity.

There was no significant correlation between physical activity and muscle endurance through push-ups and wall squats. This is the same as a study conducted by Saluy et al. (2022), which showed that there was no significant correlation between physical activity and muscle endurance with p 0.102 (Saluy et al., 2022).

Increasing activity to build muscle endurance requires resistance training with sufficient volume, frequency, and intensity, which is carried out routinely. Muscle endurance training or resistance training for beginners can be carried out with a frequency of 2-3 times per week (Fitranti et al., 2022). Physical activity has a significant influence on a person's fitness level. If physical activity such as physical exercise is not carried out in a structured manner, then the fitness level such as muscle endurance which can affect the push-up and wall squat tests will also be less good (Setiawan et al., 2022).

Other factors related to muscle endurance are age and oxygen supply. Age had a significant positive correlation with muscle endurance among adolescents. This alteration was associated with a low level of physical activity, inadequate nutritional intake, and hormonal fluctuations (Sarah et al., 2019). The efficiency of oxygen delivery to active muscles is determined by aerobic capacity (VO_2max). An increased aerobic capacity increases oxygen supply and enhances muscle endurance (Nemoto et al., 2024).

CONCLUSION

Almost all of the respondents' protein and magnesium intake was in the insufficient category. Most of the respondents had good nutritional status. Most of the respondents' muscle endurance through push-ups and wall squats was still in the poor and very poor. There was no significant relationship between nutritional status, protein intake, magnesium, and physical activity with push-ups and wall squat muscle endurance.

Based on the results of this study, students are advised to consume main meals in the form of real food according to their needs reduce fast food consumption, and increase animal and vegetable protein intake at every main meal so that nutritional intake from protein can be met.

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