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CORRELATION BETWEEN BODY MASS INDEX, MUSCLE MASS, AND MUSCLE EXPLOSIVE POWER IN FIRST-YEAR MEDICAL STUDENTS OF DIPONEGORO UNIVERSITY

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ABSTRACT

Background: Muscle explosive power as a component of physical fitness was an important factor that supports athletic performance in most sports. Jump height and vertical jump performance in assessing explosive muscle power were influenced by various factors, including physiological, biomechanical, and anthropometric factors. Body mass index, muscle mass, and fat mass were important anthropometric factors in supporting jumping performance. **Objective:** To analyze the relationship between body mass index and muscle mass with legs muscle explosive power in first-year medical students of Diponegoro University. **Methods:** This study was an observational analytic study with a cross-sectional design. The subjects consisted of 60 males and 108 females in first-year medical students of Diponegoro University who met the criteria. Body mass index and muscle mass were measured by Omron bioelectrical impedance analyzer, and muscle explosive power was measured by vertical jump test. Data were analyzed with the Kolmogorov Smirnov normality test and Spearman correlation test. **Results:** The average value of body mass index was 21.760±2.7734, muscle mass was 29.468±4.3283, and muscle explosive power was 29.468±4.3283. Muscle mass was positively correlated with legs muscle explosive power (p=0.00, R= 0.583) and negatively correlated between body mass index and legs muscle explosive power but it was not statistically significant (p=0.823 dan R=- 0.017) in first-year medical students of Diponegoro University. **Conclusion:** Muscle mass was positively correlated with legs muscle explosive power and body mass index showed no significant correlation with muscle explosive power.

Keywords: *body mass index, muscle explosive power, muscle mass, vertical jump test*

INTRODUCTION

Explosive power as a component of physical fitness is the main characteristic supporting athletic performance in most sports that require jumping, changing direction, or the ability to run fast.[1] Height and vertical jump performance in assessing muscle explosive power are influenced by various factors, including physiological, biomechanical, and anthropometric factors. Body mass index, muscle mass, and fat mass are important anthropometric factors to support jumping performance.

Explosive power can be measured by simple tests involving the ability to run fast, vertical and horizontal jump, or throw.[2] One of the commonly used tests is the vertical jump test.[3] The normal body mass index group has the mean height of vertical jump by 32±6,0 cm, meanwhile, the overweight and obese body mass index group has about 27± 7,8 cm.[1] Body mass index or BMI is the easiest method to predict the obese index on persons based on their height and body mass, however, BMI unable to distinguish the mass of fat, muscle, or bones thus unable to describe the healthy risks equally to all races or ethnicity.[4]

The explosive power of leg muscles has a significant positive correlation to the component of muscle mass and lean body mass, also somatotype mesomorphy.[3] Muscle size affects the strength and the ability to jump. The increase in the transversal size of muscle indicates more sarcomeres work as the muscle contracts, and more cross-linking, which results in greater explosive power.[3]

METHODS

The study was an observational analytic study with a cross-sectional design that was held on October 5th – 8th 2020 in the Faculty of Medicine, Diponegoro University, Semarang. This study measures the body mass index, muscle mass, and explosive power of 168 first-year medical students of Diponegoro University. The subjects were taken with the purposive sampling method and had previously given informed consent using Google Form as an online platform who met inclusion criteria; First-year of medical Students of Diponegoro University, Inferior and superior extremities are normal and able to perform vertical jump tests, and Willing to participate in research by signing informed consent and exclusion criteria; having any leg injury, history of leg injury, posture abnormality, muscle stiffness, and categorized as obese measured by Body mass index ratio.

Body mass index and muscle mass were assessed using Omron digital scale, and explosive power was assessed using the vertical jump test. All of the data were numerical. The normality of data distribution is determined using the Kolmogorov-Smirnov test. Pearson test is used when the data distribute normally, while the Spearman test is used if the data do not show normal distribution. The multiple regression method is used for multivariate analysis. The results are considered significant with p<0,05 for bivariate and F<0,05 for multivariate analysis. Statistical analysis is performed using IBM SPSS Statistics 26.0 Software.

RESULTS

We collected 168 medical students of Diponegoro University as subjects for this study. The characteristic of the subjects is shown in Table 1. There were 60 men and 108 women. Their ages ranged from 17 – 21 years old. The mean BMI was 21.76 kg/m2 and the values ranged from 16 – 27.3 kg/m2. Participant in this study had the average percentage of muscle mass 29.4±4.4 and the average of muscle explosive power 35.4±11.3.

Table 1. Characteristics of the subjects

Characteristics		N (%)	Mean±SD;median (min-max)
Sex	Male	60 (35.7)	
	Female	108 (64.3)	
	Total	168 (100)	
Age (year)	17	4 (2.4)	
	18	58 (34.5)	
	19	81 (48.2)	18.77±0.772;19 (17-21)
	20	22 (13.1)	
	21	3 (1.8)	
Body mass index	Underweight (<18,5)	24 (14.3)	
	Normal (18,5 -22,9)	91 (54.2)	21.76±0.277;21.85 (16-27.3)
	Overweight (23- 27,5)	53 (31.5)	
Muscle mass			29.468±4.428;28 (18.8-38.6)
Explosive power			35.447±11.3704;32 (16 – 67)

*SD: Standard Deviation; Min: Minimum; Max: Maximum; n: number of subjects

Table 2. *Kolmogororv Smirnov* normality test

Variable	Statistic	df	Sig
Body mass index	0.052	168	0.200*
Muscle mass	0.157	168	0.000
Explosive power	0.408	168	0.000

*Significant (p>0.05)

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Based on the normality test using the Kolmogorov Smirnov test, the results of body mass index were normally distributed (p>0.05), while the results of muscle mass and explosive power were both not normally distributed (p<0.05). Thus, all of them are directed to Spearman's test to find out their intervariable relationship.

Table 3. *Spearman* test and Simultaneous correlation strength between body mass index, muscle mass, and explosive power

Variable	Explosive power		Multiple correlation test		
	p[¶]	R[£]	p[¶]	R[£]	R-square[§]
Body mass index	0.823	- 0.017	0.027*	0.207	0.031
Muscle mass	0.000*	0.583	0.027*	0.207	0.031

[¶]*Spearman;* *Significant(p<0.05); [£]Correlation coefficient; [§]*Adjusted R-square*

The result of Spearman test revealed that Body Mass Index and explosive power had a negative correlation but it was not statistically significant (p=0.82; R=- 0.017), then muscle mass and muscle explosive power showed a significant positive correlation (p=0,000) with moderate strength (r=0,583). While multiple correlation test showed that body mass index and muscle mass have a significant positive correlation (p = 0.027) with weak strength (r = 0.207) towards muscle explosive power.

DISCUSSION

Body Mass Index and muscle explosive power showed a negative relationship but it was not statistically significant (p = 0.823 and R = - 0.017). This is similar to the research of Andrija Atanasković and Vladimir Mutavdzić (2015) which showed no statistical significance but showed a negative relationship in the Pearson correlation test between body mass index and two variables of strength and explosive power (p = 0.835 R = -0.056 ; p = 0.951 R = -0.017).[5] The study of Djokic et al. showed that overweight has a negative correlation with the power of leg muscles, where someone who is overweight or obese has a lower vertical jump compared to someone with a normal body mass index.[6]

Assessment on body weight and BMI alone tends to be less accurate, this is because the BMI scale cannot distinguish the proportion of body composition consisting of fat mass, lean body mass, and muscle mass. Thus an athlete who has more muscle than a non-athlete will be more likely to be categorized as overweight according to their weight and BMI calculation, even though they are not actually in the overweight category. Thus, there is a contradiction in the value of vertical jumps between those who are overweight and those who are miscategorized.[7]

Muscle mass and muscle explosive power showed a significant correlation with moderate strength and positive relationships between the two (R = 0.583). This is similar to the previous research conducted by Saha et al. which showed that the percentage of skeletal muscle mass, lean body mass, thigh circumference, calf circumference, and mesomorph somatotype components were significantly correlated positively with the explosive power of athlete's and non-athlete men at Indian universities[3] and in the study of Białoskórska et al. also showed a significant correlation between vertical jumping skills and body composition of volleyball players, there was a positive correlation between vertical jump height and muscle mass and a negative correlation between body fat percentage and body mass index.[8]

The jump height and vertical jump performance are influenced by various factors, including physiological, biomechanical, and anthropometric factors. Bodyweight, fat mass, and muscle mass are important anthropometric factors to support jumping performance.[9] To get a high vertical jump value, maximum muscle contraction is required. The main structure of skeletal muscle is the myofibrils which are an important unit of skeletal muscle, contain contractile protein elements that cause muscles to contract. Muscle size affects the strength and ability of the jump where an increase in the transversal size of the muscle indicates more sarcomere acting when the muscle contracts and more cross-linking that occurs, resulting in greater explosive power.[3]

The muscles that play a role in doing vertical jumps are the lower leg muscles which consist of three parts; the adductors (*m. adductor langus, m. adductor brevis, m. adductor magnus, m. pectineus, and m. gracillis*), the extensors (*m. quadriceps femoris, m. rectus femoris, m. vastus lateralis, m. vastus medialis, m. vastus intermedius and m. sartorius*); and hamstrings (*m. biceps femoris, m. semi tendinosus, m. semi membranosus*)[10] and the role of the upper extremity muscles. Arm muscle hypertrophy substantially contributes to the improvement of performance, upper limb muscle volume gain 22% higher during strenuous resistance training in junior handball players and increase in muscle volume by 27% in handball players after 12 weeks of specific resistance training.[11]

Muscle explosive power is measured by vertical jump test, where the respondent is asked to jump as much as possible from a semi-squat position with their arm straightened and attached to the measuring board. Limitations or errors that may occur are in the reading of the highest scale of the jump that was done manually leading to possibe mistake and the vertical jump test technique that was not excecuted properly. So in the future research, digital vertical jump boards can be used to get more accurate values, and it was also suggested to do vertical jump training prior to measurement to get better technique.

CONCLUSION

This study concludes that muscle mass has a positive correlation with muscle explosive power, and body mass index does not have a significant correlation with muscle explosive power. This research can be used as a basis for further research (cohort research) on the relationship between body mass index and muscle mass to muscle explosiveness and further research on the relationship between body mass index and muscle mass to muscle explosive power can be carried out by adding other variables such as fat mass, WHR, height, athletes and non-athletes.

Ethical Approval

All research procedures received ethical clearance from the Health Research Ethics Commission of the Faculty of Medicine, UNDIP Semarang before conducting the research. The Ethical Clearance number is 48/EC/KEPK/FK-UNDIP/VI/2020.

Conflicts of Interest

The authors declare no conflict of interest.

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Author Contributions

Writing-original draft preparation, Devi Wahyu Arum Sari, Hafizhil Uzhma Al Ahmadi, Timothy Jordan; writing-review and editing,dr. Darmawati Ayu Indraswari M.Si.Med, dr. Edwin Basyar, M.kes.,Sp.B.,Sp.BA, dr. Buwono Puruhito, Sp.KK.

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