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ORIGINAL PAPER

Association between muscle-to-visceral fat ratio and vascular elasticity in medical students

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Abstract

Background: Medical students often adopt lifestyles that contribute to decreased muscle mass and increased visceral fat accumulation, which can negatively impact vascular elasticity, a biomarker for the early detection of cardiovascular disease.

Objective: This study aims to evaluate the association between the muscle mass to visceral fat ratio and vascular elasticity in medical students at Universitas Pembangunan Nasional Veteran Jakarta (UPNVJ).

Methods: A cross-sectional design was conducted from November 2023 to January 2024 at UPNVJ. The sample consisted of 51 subjects who met the research criteria. The muscle-to-visceral fat (MVF) ratio was measured using Bioelectrical Impedance Analysis (BIA), while vascular elasticity was assessed using the Accelerated Photo plethysmograph Analyzer SA-3000P.

Results: The results revealed that 68.6% of the subjects had the lowest MVF ratio and 54.9% exhibited sub-optimal vascular elasticity. No differences were found in age, gender, physical activity, or eating habits between the vascular elasticity groups ($p > 0.05$). The Chi-square test revealed a significant association between the MVF ratio and vascular elasticity ($p = 0.009$; OR = 6.545; 95% CI = 1.7–24.9).

Conclusion: Students with the lowest MVF ratio were found to be 6.54 times more likely to have sub-optimal vascular elasticity, compared to those with low and high MVF ratios, indicating an increased risk of cardiovascular disease. These findings underscore the importance of early preventive intervention aimed at optimizing body composition through targeted wellness programs. The implementation of nutritional education and structured physical activity initiatives, particularly in young adults, may play a critical role in reducing the risk of cardiovascular disease.

Keywords: muscle mass, vascular elasticity, visceral fat

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Introduction

Cardiovascular disease (CVD) is the leading cause of death worldwide. In 2019, the World Health Organization estimated that 17.9 million people died from CVD, accounting for 32% of all global deaths.[1] Early identification of high-risk individuals can be facilitated using biomarkers.[2] Vascular elasticity is a novel biomarker for CVD.[3] Reduced vascular elasticity impedes blood flow and increases the left ventricle's workload, leading to elevated blood pressure. Consequently, decreased vascular elasticity heightens the risk of CVD.[4]

Physical inactivity is a recognized cardiovascular risk factor associated with changes in body composition. In Indonesia, the prevalence of physical inactivity increased from 26.1% in 2013 to 33.5% in 2018.[5] Lack of physical activity contributes to muscle mass loss and obesity.[6] The combined effects of muscle mass loss and visceral fat accumulation contribute to cardiometabolic diseases in young adults.[7] Studies show that obesity accelerates vascular aging from early adolescence.[8] Central obesity, characterized by visceral fat accumulation, is independently associated with metabolic disorders such as insulin resistance and cardiovascular conditions.[9] Additionally, reduced muscle mass is linked to insulin resistance, which contributes to endothelial dysfunction and vascular stiffness.[10] Moreover, muscle mass loss and visceral fat accumulation are interrelated through the synthesis of pro-inflammatory cytokines, which directly impact vascular elasticity.[11] Thus, the muscle-to-visceral fat (MVF) ratio serves as a stronger predictor of cardiometabolic diseases than muscle mass or visceral fat alone.[12]

A study at Universitas Pembangunan Nasional Veteran Jakarta (UPNVJ) in 2020 found that 47% of 150 medical students were obese, with most engaging in light physical activity.[13] This may be attributed to the demanding academic schedules of medical students, leading to increased food intake and neglect of physical activity, resulting in alterations to the MVF ratio. Such alterations are associated with metabolic disorders that may increase the risk of cardiovascular diseases.[11]

While physical activity remains important, dietary habits have been shown to exert an even greater influence on body mass index (BMI). Among medical students, common dietary habits include irregular meals, frequent meal skipping, inadequate consumption of fruits and vegetables, and high intake of candies, alcohol, fried foods, and fast food.[14] These poor dietary habits, in conjunction with a sedentary lifestyle, further contribute to adverse changes in the MVF ratio within this population. However, the impact of the MVF ratio on vascular elasticity in young adults, particularly among medical students, remains unexplored. Therefore, this study aims to evaluate the association between the MVF ratio and vascular elasticity in medical students at UPNVJ in 2023.

Methods

The study utilized an analytical cross-sectional design conducted in November 2023 - January 2024 at the Laboratory Unit of Physiology and Nutrition, Medical Education and Research Center of UPNVJ. The study population comprised 533 medical students from the Faculty of Medicine UPNVJ.

The research subjects were medical students from the 2023/2024 academic year who met the inclusion criteria, which included being at least 18 years old and engaging in light or moderate physical activity. Exclusion criteria included a history or diagnosis of diabetes mellitus or cardiovascular diseases (e.g., hypertension, chronic heart failure, myocardial infarction, and peripheral artery disease), as well as smoking or alcohol consumption.

The sample size was calculated using a two-proportion formula with $\alpha = 5\%$, $\beta = 80\%$, $P_1 = 0.76$, and $P_2 = 0.4$, based on studies by Liu et al. (2021)[15] and Xu et al. (2018)[11], resulting in a sample of 46 subjects. To account for a potential 10% dropout rate, the minimum required sample size was increased to 51 subjects. The subjects were selected using stratified random sampling according to their year of admission to the Faculty of Medicine.

Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ), which measures activity in Metabolic Equivalent of Task (MET) units over the past month. The GPAQ demonstrated moderate to strong reliability for calculating total physical activity time (Spearman's rho: 0.68–0.79). Physical activity levels were categorized as vigorous (MET ≥ 3000), moderate (600 ≤ MET < 3000), and light (MET < 600).[16]

Eating habits were evaluated using the Adolescent Food Habits Checklist (AFHC), which was translated into Indonesian. AFHC scores were categorized into two groups: good eating habits (scores ≥ mean) and poor eating habits (scores ≤ mean). The validity and reliability of this tool were established, with a Cronbach's alpha of 0.86.[17]

Body composition was measured using the Body Composition Analyzer (Tanita MC-980MA Plus), which has 80% sensitivity and 90% specificity.[18] Subjects were instructed to remove all metal accessories, stand barefoot on the analyzer, and hold the electrodes for 30 seconds. The MVF ratio was categorized into four groups: lowest ratio (Q1): 2.62–15.3; low (Q2): 15.4 – 37.4; high (Q3): 37.5 – 42.7; and very high (Q4): 42.8 – 73.3.[12]

Vascular elasticity was measured using the Accelerated Photoplethysmography (APG) SA-3000P, which has 71.4% sensitivity and 90% specificity. Subjects were instructed to remove metal accessories and sit comfortably while the APG sensor was clipped onto the index fingertip for three minutes. Vascular elasticity results were categorized as sub-optimal (<30), normal (30-70), or optimal (>70).[19]

Univariate analysis was conducted to describe the subjects' characteristics, physical activity, eating habits, MVF ratio, and vascular elasticity. The Chi-square test was used to test the hypothesis of an association between MVF ratio and vascular elasticity. If the assumptions for the Chi-square test were not met, the exact Chi-square test was used as an alternative. The data were analyzed using SPSS software.

This study received ethical clearance from the Health Research Ethics Committee of UPNVJ, with approval number 417/XI/2023/KEPK.

Results

The subjects of this study were first-, second-, and third-year medical students of UPNVJ, aged between 18 and 22 years. In the study, 84 out of 120 students who completed the questionnaire met the study's criteria. Stratified random sampling was used to select 51 subjects who met the criteria. The data on the subjects' characteristics reveal that the median age was 20 years. Most subjects were female, engaged in moderate physical activity, and exhibited poor eating habits. **Table 1** indicates no significant differences in age, gender, physical activity, and eating habits between the vascular elasticity groups (p > 0.05).

Table 1. Characteristics of subjects (N = 51)

No	Characteristics	Vascular Elasticity		p-value
		Sub-optimal N = 28	Normal+Optimal N = 23	
1.	Age, median (min-max)	20 (18-22)	20 (18-21)	0.984[a]
2.	Gender, n (%)			
	Male	10 (58.8)	7 (41.2)	0.921[b]
	Female	18 (52.9)	16 (47.1)	
3.	Physical Activity, n (%)			
	Light	14 (66.7)	7 (33.3)	0.260[b]
	Moderate	14 (46.7)	16 (53.3)	
4.	Eating Habits, n (%)			
	Good	13 (52)	12 (48)	0.899[b]
	Poor	15 (57.7)	11 (42.3)	

Note: [a]Mann-Whitney test, [b]Chi-square test

In this study, 35 subjects (68.6%) had an MVF ratio ranging from 2.62 to 15.3, categorized as Q1, indicating that most of the subjects had the lowest ratio of MVF. This was followed by 14 subjects (27.5%) in Q2 (MVF ratio: 15.4 – 37.4) and 2 subjects (3.9%) in Q3 (MVF ratio: 37.5 –

42.7). Notably, no subjects were categorized into Q4 (MVF ratio: 42.8–73.3) (**Figure 1**).

In this study, 28 subjects (54.9%) exhibited sub-optimal vascular elasticity (<30), 20 subjects (39.2%) had normal vascular elasticity (30-70), and 3 subjects (5.9%) had optimal vascular elasticity (>70) (**Figure 2**).

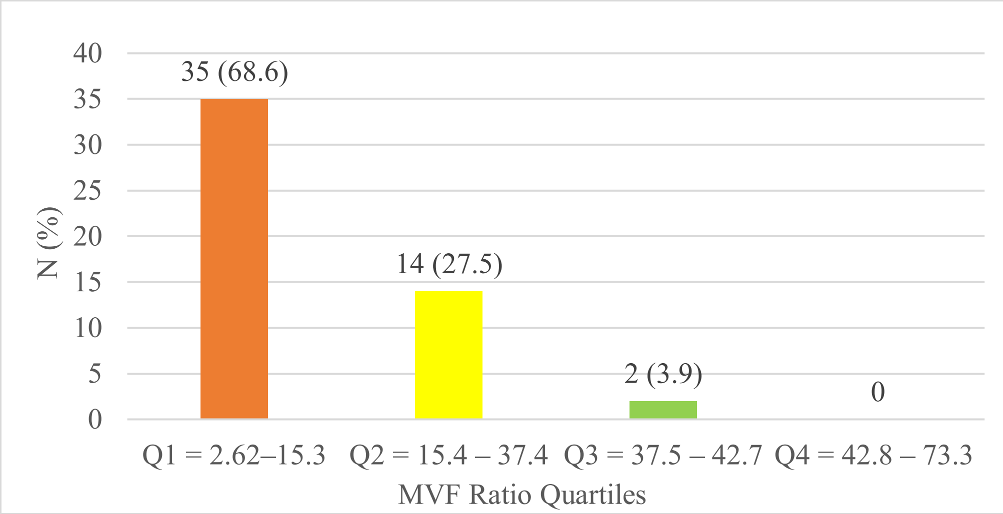

Figure 1. Muscle-to-visceral fat ratio of subjects

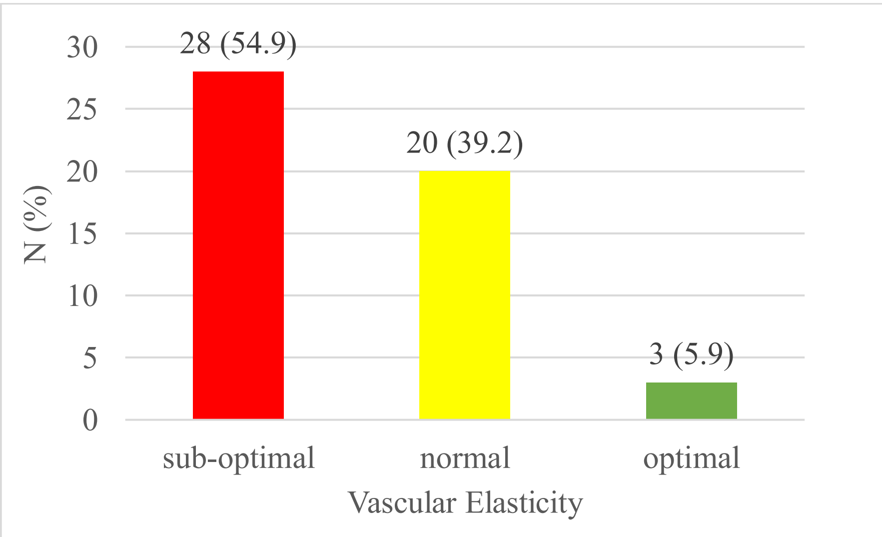

Figure 2. Vascular elasticity of subjects

The results of the Chi-square test revealed a significant association between the MVF ratio and vascular elasticity ($p = 0.009$; OR = 6.545; CI = 1.7 – 24.9) (Table 2), indicating that subjects with an MVF ratio of Q1 are 6.5 times more likely to have sub-optimal vascular elasticity compared to those in Q2 & Q3.

Table 2. The association between MVF ratio and vascular elasticity

MVF Ratio	Vascular Elasticity				Total		p-value	OR (95% CI)
	Sub-optimal		Normal+Optimal					
	N	%	N	%	N	%		
Q1	24	68.6	11	31.4	35	100	0.009	6.545
Q2 & Q3	4	25	12	75	16	100		(1.7 – 24.9)

Discussion

The results of this study indicate that most subjects had the lowest MVF ratio (Q1). This suggests that most subjects had low muscle mass and high visceral fat. This finding is consistent with a study conducted on university students in China, which found that 24.2% of participants experienced an increase in visceral fat percentage and a decrease in muscle mass percentage due to unhealthy lifestyles. The lack of leisure time and insufficient sleep among students reduces the time available for exercise, while increased reliance on internet use further detracts from physical activity.[20]

Another study reported that students expend only 1375.94 kcal daily due to sedentary lifestyles, which is 443 kcal less than the 1818 kcal required to maintain an ideal body composition. This contributes to 78% of subjects having high body fat and an imbalanced body composition.[21] A study conducted in 2022 among physiotherapy students at UPNVJ showed that students had high body fat percentages, with 76.5% of female subjects and 40.9% of male subjects exhibiting elevated fat levels. The increase in pro-inflammatory cytokine secretion from fat accumulation leads to protein catabolism and inhibition of muscle protein synthesis, causing students with higher fat levels to exhibit low muscle mass. Therefore, regular screening of body composition is essential to identify potential health problems.[22]

This study found that 28 subjects (54.9%) had sub-optimal vascular elasticity. This finding aligns with a study conducted in Sweden, which showed that 12% of young subjects exhibited vascular stiffness, thereby increasing their risk of cardiovascular disease. In that study, 24% of subjects consumed unhealthy foods, and 24% did not engage in recommended physical activity. Low physical activity and excessive nutritional intake in youth significantly contribute to vascular stiffness.[23] Additionally, a study indicated that vascular stiffness could begin as early as age 17. Measurements taken over seven years revealed that high body fat composition at the onset of puberty reduces elastin fiber thickness, increasing vascular wall tension and pressure. This leads to collagen accumulation and vascular stiffness.[24]

The data on subject characteristics revealed that the median age of the study participants was 20 years. Age influences vascular elasticity due to elastin fiber fragmentation and collagen deposition over time.[25] Age significantly impacts vascular stiffness in individuals over 60.[26] However, this study found no significant age difference between the vascular elasticity groups (p = 0.286) (Table 1), suggesting that age did not influence vascular elasticity in this study. This lack of significance may be attributed to the narrow age range of the study population, which is distinctly younger than the typical age group in which changes in vascular elasticity commonly begin to appear.

The research subjects included 34 females and 17 males, which reflects the higher number of female students at the Faculty of Medicine UPNVJ.[27] Sex hormones are known to play protective roles in vascular health. Differences in estrogen levels between females and males contribute to variations in vascular elasticity. High estrogen levels enhance nitric oxide (NO) bioavailability and reduce vascular stiffness.[28] Estrogen also protects vascular health by reducing reactive oxygen species (ROS) production. However, in young females with abundant lipid tissue, endothelial cell mineralocorticoid receptors play a critical role, stimulating sodium ion channel activation and oxidative stress, which can reduce vascular elasticity.[29] No significant gender differences were found between the vascular elasticity groups (p = 0.921) (Table 1), suggesting that gender did not influence vascular elasticity in this study.

Physical activity influences vascular elasticity by increasing blood flow and shear stress, which triggers NO secretion. Increased NO availability causes smooth muscle relaxation in response to constant pressure from increased blood flow. Regular exercise induces endothelial adaptation, improving perfusion, reducing the risk of endothelial dysfunction, and improving vascular stiffness.[30] Another study highlighted that moderate-intensity physical activity for 150 minutes or high-intensity physical activity for 75 minutes per week positively impacts arterial stiffness.[31] This study categorized subjects' physical activity as light and moderate. However, no significant difference in physical activity was observed between the vascular elasticity groups ($p = 0.260$) (**Table 1**), suggesting that physical activity did not influence vascular elasticity differences in this study.

Eating habits scores revealed that most subjects with poor eating habits had sub-optimal vascular elasticity (57.7%). Eating habits are known to impact vascular elasticity, with studies indicating that unhealthy diets, such as increased fat and salt intake, are associated with increased vascular stiffness. Excessive fat intake leads to vascular remodelling, a process involved in atherosclerotic plaque formation. High salt intake also increases ROS production and reduces NO bioavailability.[32] However, this study found no significant difference in eating habits between the vascular elasticity groups ($p = 0.899$) (Table 1). This finding may be attributed to the limited sample size, which could have reduced the statistical power to detect meaningful differences. This finding aligns with a 2020 study that showed no association between eating habits and vascular stiffness in a cross-sectional design. However, eating habits significantly influence vascular elasticity in longitudinal studies over an average of seven years, as subclinical diseases like arterial stiffness tend to develop after prolonged exposure.[33]

The Chi-square test revealed a significant relationship between the MVF ratio and vascular elasticity ($p = 0.009$). An odds ratio (OR) of 6.54 indicates that individuals with the lowest MVF ratio are 6.5 times more likely to have sub-optimal vascular elasticity compared to those in Q2 & Q3 (Table 2). This finding is consistent with a study on type 2 diabetes mellitus patients in China, where the MVF ratio was measured using a dual bioelectrical impedance analyzer (dual-BIA), and vascular elasticity was assessed using brachial-ankle Pulse Wave Velocity (baPWV). This study found a significant association between the MVF ratio and vascular elasticity (OR = 4.33 for males, OR = 4.66 for females, $p < 0.01$). This relationship can be explained by the theory that a low MVF ratio induces insulin resistance. Muscles play a critical role in insulin-mediated glucose absorption, and reduced muscle mass decreases insulin receptor numbers, leading to insulin resistance. Increased visceral fat also correlates with heightened insulin resistance. Moreover, a low MVF ratio stimulates inflammatory cytokine secretion, contributing to vascular stiffness.[11] Another study demonstrated that a low MVF ratio was significantly associated with an increased 10-year cardiovascular disease risk ($p < 0.001$). The development of insulin resistance in subjects with a low MVF ratio negatively affects vascular elasticity, suggesting an elevated cardiovascular disease risk.[15] A study on Colombian students aged 18-30 found that the MVF ratio was significantly associated with metabolic syndrome ($p<0.001$). Metabolic syndrome is independently associated with vascular elasticity due to visceral fat accumulation, which triggers metabolic changes in adipose tissue, including free fatty acid flux dysregulation, oxidative stress, and increased inflammatory cytokines, leading to insulin resistance.[12]

This study categorized eating habits based on AFHC scores, but a more detailed nutritional assessment (e.g., macronutrient breakdown, specific micronutrient intake) would provide deeper insights into the relationship between diet and vascular elasticity.

This study has several limitations that should be considered when interpreting the findings. First, the study population consisted of a small sample of medical students from a single institution, which may limit the generalizability of the results to broader or more diverse populations. Second, several potential confounding variables, such as dietary patterns, stress levels, and sleep quality were not fully controlled or measured. The absence of multivariate analysis to adjust for these confounders may have influenced the observed associations. Additionally, potential measurement biases, such as variations in hydration status that may affect the accuracy of bioelectrical impedance analysis (BIA), were not addressed in this study.

Conclusion

Based on the data and analysis of the research findings, it can be concluded that there is a significant association between the MVF ratio and vascular elasticity. Subjects with the lowest MVF ratio are 6.54 times more likely to have sub-optimal vascular elasticity. The finding matters because it highlights a significant association between a low muscle-to-visceral fat (MVF) ratio and sub-optimal vascular elasticity, indicating an elevated risk of early cardiovascular disease even in young adults, such as medical students. It underscores the importance of maintaining a healthy body composition early in life to mitigate long-term cardiovascular disease risk. Considering the limitation of this study, future research should involve a larger and more diverse population across multiple institutions, employ multivariate statistical approaches to control for confounders, and consider interventional study designs to evaluate whether improving the MVF ratio through dietary and exercise interventions can enhance vascular elasticity and reduce the risk of cardiovascular disease.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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