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RELATIONSHIP OF DIETARY INTAKE AND PHYSICAL ACTIVITY WITH BODY COMPOSITION IN ADULTS: A CASE-CONTROL STUDY

Hubungan Konsumsi Makanan dan Aktivitas Fisik dengan Komposisi Tubuh pada Orang Dewasa: Studi Kasus-Kontrol

Inggrit Bela Thesman[1] , Dono Indarto[1,2,3,4], Yuliana Heri Suselo[1,2,3,4]

[1]Master Program of Nutritional Sciences, Graduate School, Universitas Sebelas Maret, Surakarta, Indonesia

[2]Biomedical Laboratory, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

[3]Department of Physiology, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

[4]Tropical Herbal Medicine, Research Center, Universitas Sebelas Maret, Surakarta, Indonesia

*Email: yulianaheri@staff.uns.ac.id

ABSTRAK

Obesitas yang ditandai dengan kelebihan lemak tubuh dan gangguan komposisi tubuh menyebabkan gangguan kesehatan dan risiko tinggi terhadap kasus penyakit tidak menular. Penelitian ini bertujuan untuk mengevaluasi hubungan antara asupan karbohidrat, lemak, protein, serta aktivitas fisik dengan persentase lemak visceral dan massa otot pada individu dewasa yang mengalami obesitas. Studi analitik observasional ini menggunakan desain kasus kontrol, dengan merekrut 25 partisipan dengan status berat badan normal dan 25 partisipan obesitas. Pengumpulan data dilakukan menggunakan Semi Quantitative Food Frequency Questionnaire (SQFFQ) dan aktivitas fisik dinilai menggunakan International Physical Activity Questionnaire-Short Form (IPAQ-SF). Asupan makan dan aktivitas fisik tidak berhubungan dengan persentase lemak sementara, regresi linear ganda menunjukkan bahwa asupan karbohidrat (B = 0,007, β = 0,171, p = 0,028), aktivitas fisik (B = -0,001, β = -0,200, p = 0,028), jenis kelamin (B = 6,041, β = 0,522, p < 0,001), dan BMI (B = -1,021, β = -0,961, p < 0,001) merupakan prediktor signifikan untuk persentase massa otot. Temuan penelitian ini menunjukkan bahwa terdapat hubungan yang signifikan antara asupan karbohidrat dan aktivitas fisik dengan persentase massa otot setelah disesuaikan dengan faktor perancu. Konsumsi karbohidrat disertai aktivitas fisik dapat meningkatkan massa otot.

***Kata kunci**: Aktivitas fisik, asupan makanan, lemak viseral, massa otot, obesitas*

ABSTRACT

Obesity characterized by excess body fat and altered body composition resulting in impairment of health and high risks of numerous noncommunicable diseases. This research sought to examine how the intake of carbohydrates, fats, and proteins, as well as levels of physical activity, are associated with visceral fat and muscle mass percentages in adults with obesity. This observational analytic research employed a case-control design, enrolling 25 normoweight and 25 obese adult participants. Dietary intake data were gathered using a Semi-Quantitative Food Frequency Questionnaire (SQFFQ), while physical activity levels were measured with the International Physical Activity Questionnaire-Short Form (IPAQ-SF). While dietary intake and physical activity showed no significant correlation with visceral fat percentage, a multiple linear regression analysis revealed that carbohydrate intake (B = 0.007, β = 0.171, p = 0.028), physical activity (B = -0.001, β = -0.200, p = 0.028), sex (B = 6.041, β = 0.522, p < 0.001), and BMI (B = -1.021, β = -0.961, p < 0.001) for muscle mass percentage were identified as significant predictors. The results of this research show that after controlling for

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confounding variables, a significant association was found between both carbohydrate intake and physical activity with muscle mass percentage. Consuming carbohydrates and engaging in physical activity can help increase muscle mass percentage.

Keywords: Dietary intake, muscle mass, obesity, physical activity, visceral fat

INTRODUCTION

Obesity characterized by excess body fat and altered body composition resulting in impairment of health and high risks of numerous noncommunicable diseases. [1], [2]. The World Health Organization (WHO) 2024 [3] reported that 2.5 billion adults worldwide were estimated to be overweight in 2022 and 890 million were obese. Based on the Indonesian Health Survey (Survei Kesehatan Indonesia) [4], the prevalence of overweight and obesity was 14.4% and 23.4%, respectively.

Body composition, which includes muscle mass, bone, visceral fat, and body water, plays a crucial role in maintaining physiological function and metabolic health [5]. Among these components, visceral fat and muscle mass are particularly important health indicators [6]. Visceral fat is the body fat stored around internal organs [7], [8], [9] and is particularly associated with a higher risk of cardiometabolic, including insulin resistance and inflamation [10]. Conversely, muscle mass supports metabolic rate, glucose regulation, and physical function [11].

Macronutrient intake and physical activity are key factors influencing body composition. Zamanillo-Campos, et al.[12] reported that, after a 12-month follow-up, participants with higher quality carbohydrate intake experienced a significant decrease in visceral fat (β = -0.067 z-score, 95% CI: -0.088 to -0.046, p < 0.001). Similarly, Pescari, et al. [13] found that a high-protein diet was associated with a 3.61% increase in muscle mass (95% CI: 0.12 to 7.11, *p* = 0.043), highlighting the importance of protein in muscle preservation. In addition, Leite et al. [14] reported that the combination of regular physical activity and balanced nutritional intake significantly improved the muscle-to-fat mass ratio in individuals. There are also conflicting findings regarding the role of dietary in body composition. For example, Davoudzadeh et al. [15] found that there was no significant correlation between non-healthy diet index with body composition (*p* >0,05), while other studies have reported a significant correlation. These gaps in the literature form the basis for the present study.

Recent research also has highlighted that body composition is shaped by a complex interplay of biological, socioeconomic, and demographic factors, each contributing uniquely to the risk of obesity, sarcopenia, and related metabolic disorders [16], [17], [8], Age is the primary determinant of body composition. With advancing age, individuals typically experience a progressive decline in muscle mass and a concomitant increase in visceral fat accumulation [16]. Sex also plays a significant role, with men and women exhibiting distinct patterns of fat distribution and muscle retention [8]. Lower socioeconomic status is consistently associated with higher rates of obesity in high-income countries, while transitions in middle-income countries may lead to increased obesity risk among higher socioeconomic groups [18]. Education level and occupation also affect dietary patterns and physical activity, thereby shaping fat and muscle distribution [19]. This study aimed to investigate the relationship between carbohydrate, fat, protein intake, and physical activity with visceral fat and muscle mass percentage in obese adults.

METHODS

Study Subjects

This study employed a case-control design to assess the associations at a single point in time. The study took place at Universitas Sebelas Maret (UNS) in Surakarta, Indonesia, between October 2024 and February 2025. Sample size was calculated using the odds ratio formula by Rahmah [18], with an estimated odds ratio of 5.64 for adults

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with obesity. The minimum sample was 25 per criterion, as calculated using the OpenEpi program (https://www.openepi.com/SampleSize). A total of 50 healthy adult participants, both male and female, aged 18–30 years, were recruited for the study. They were divided into two groups a case group and a control group based on predetermined inclusion and exclusion criteria.The case group consisted of individuals with a body mass index (BMI) of ≥25 kg/m², while the control group included those with a BMI from 18.5 to 24.9 kg/m², based on the World Health Organization (WHO) 2002 BMI classification. Participants were excluded they consumed supplements related to obesity, individuals using medications that influence weight, such as psychiatric drugs (e.g., antidepressants), beta blockers, diuretics, contraceptives or steroids. Additionally, individuals who were pregnant, had conditions that could cause secondary obesity, or had comorbidities such as Alzheimer's disease, stroke, coronary heart disease, kidney disease, or liver disease, were unable to exercise due to musculoskeletal disorders also not included. Participants were recruited through a poster displayed at Instagram, and individuals who satisfied the inclusion criteria reached out contact person and joined the WhatsApp group. This study received approval from The Faculty of Medicine Universitas Sebelas Maret Surakarta No: 19/UN27.06.11/KEP/EC/2025. Before data collection, each participant signed an informed consent of the study's aims, procedures, risks, and benefits.

Data Collection

Information about sex, age, medication use, and medical history illness included in the questionnaire. Education was categorized in high school and college. Occupation was categorized into four categories: Housewife/ unemployed, student, civil servant, and self-employed. Montly personal expenses was categorized: Rp <500.000, Rp 500.000-1.200.000, Rp 1.200.000-1.600.000, Rp >600.000. Certified nutrittionist were assigned to conduct the questionnaires. Data on carbohydrate, fat, and protein intake were gathered through an interview using food recall the Semi-Quantitative Food Frequency Questionnaire (SQFFQ) and analyzed with the Nutrisurvey program (www.nutrisurvey.de). Physical activity were assessed using the International Physical Activity Questionnaire Short Form (IPAQ-SF) and quantified in terms of MET minutes per week (MET/min/week). All the data was obtained through direct measurments and completed in a single session. BMI was calculated as the ratio of weight (kg) to the square of height (m^2). Body composition was determined based on HBF-214 Bioelectrical Impedance Analysis (Omron Karada Scan®, Japan) and stature meter (Gea & One®, Indonesia).

Statistical Analysis

Data were analyzed using IBM SPSS 25.0 for Windows. Nominal and ordinal variables were presented as absolute and relative frequencies [*n* (%)], while numerical variables were expressed as mean value with standard deviations (SD). A normality test was performed using the Shapiro-Wilk test to determine the distribution of the data. The characteristics of the data were analyzed using the Chi-Square test for categorical variables, while the Mann-Whitney U test was used for ratio variables that non normally distributed and t-test for normally distributed. Spearman correlation coefficients were calculated to assess relationships, with significance set at $p < 0.05$. The results are presented as odds ratios (ORs). Independent variables with a p-value > 0.25 that were not statistically significant but deemed theoretically or contextually relevant were retained for inclusion in the multivariate regression model [20]. Multivariate analysis was conducted using multiple linear regression of independent variables followed by adjustments for covariates such as age, sex, weight, BMI, educational background, occupation, and monthly personal expenses. A p-value <0.05 was considered statistically significant and 95% confidence interval (CI) were reported.

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RESULTS

Characteristics of The Study Population

The table 1 presents the characteristics of the study participants in both the case and control groups, each comprising of 25 individuals. There was no significant difference in sex distribution, occupation, or monthly personal expenses between the groups. However, an important difference was observed in educational history, with the case group having a higher proportion of participants with only a high school education (64%) compared to the control group (20%), while the control group had a larger proportion of university graduates (80% vs. 36%, p=0.002). In terms of body composition, there was a marked and statistically significant difference in visceral fat percentage (p<0.001). Muscle mass percentage also differed significantly (p=0.003). Physical activity levels tended to be lower in the case group, but this difference was not statistically significant (p=0.080). Overall, the most notable differences between the groups were in educational background, visceral fat, and muscle mass percentages.

Table 1. Characteristics of Study Participants

Variable	Case (n=25)		Control (n=25)		p-value
	n	%	n	%	
Sex					
Male	9	36	7	28	0.544
Female	16	64	18	72	
Educational History					
High school	16	64	5	20	0.002*
University	9	36	20	80	
Occupation					
Student	16	64	19	76	
Housewife/ unemployed	2	8	1	4	0.662
Civil servant	4	16	4	16	
Self-employed	3	12	1	4	
Montly personal expenses (IDR)*					
<500.000	4	16	3	12	
500.000 -1.200.000	6	24	11	44	0.520
1200.000 - 1.600.000	6	24	4	16	
>1.600.000	9	36	7	28	
Visceral fat (%)*					
Low ≤ 9	8	32	25	100	<0.001*
Normal 10-14	8	32	0	0	
High ≥15	9	36	0	0	
Muscle mass (%)*					
Low < 19.9	7	28	0	0	0.003*
Moderate 19.9-27.7	11	44	15	60	
High >27.7	7	28	10	40	
Physical activity (MET/min/week)					
Low ≤ 600	16	64	9	36	
Moderate > 600	9	36	14	56	0.080
Vigorous ≥ 3000	0		2	8	

*Criteria montly personal expenses from World Bank SUSENAS 2021
*Criteria visceral fat and muscle mass percentage from Saad, 2021

Table 2 explain that there are no significant differences in age and carbohydrate or fat intake between the two groups. However, the control group has significantly lower mean body weight and BMI compared to the case group (p<0.001 for both variables). Additionally, protein intake is notably higher in the control group than in the case group (p=0.013). These findings indicate that, aside from age and most dietary intakes, the groups differ substantially in terms of body composition and protein consumption, with the control group exhibiting healthier weight, BMI, and greater protein intake.

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Table 2. Characteristics of Study Participants

Variable	Case			Control			p[a]	p[b]
	X̄ ± SD	Min	Max	X̄ ± SD	Min	Max		
Age (years)	28.08 ± 8.9	19	44	23.6 ± 6.5	18	45	<0,001	0.069
Weight (kg)	75.4 ± 11.6	52.5	105	54.1 ± 6.2	43.7	66.6	0,39	<0.001*
BMI (kg/m^2)	29.3 ± 3.8	23	38.6	21.2 ± 1.5	18.1	24.4	0,007	<0.001*
Carbohydrate intake**	321.8 ± 147	152.5	692	313 ± 128	182.5	615.5	<0,001	0.984
Fat intake **	57.2 ± 27.6	15.9	120.5	49.3 ± 27.1	14.2	125	0,081	0.201
Protein intake	75.8 ± 37.1	31.3	183	99.8 ± 40.7	45.2	197.3	0,006	0.013*

*statistically significant
**Carbohydrate and fat intake (n=48) because of outlier data
[a]p-value for normality test (p>0.05)
[b]p-value independent t-test for normal data and Mann-Whitney U test for abnormal data

Correlation between Dietary Intake and Physical Activity with Visceral Fat and Muscle Mass Percentage

Table 3. Bivariate Analysis between Diatary Intake (Carbohydrate, Fat and Protein) and Physical Activity with Visceral Fat Percentage and Muscle Mass Percentage

	Visceral Fat (%)		Muscle Mass (%)	
Variable	r	p-value	r	p-value
Carbohydrate intake (g/day)	-0.066	0.655	0.150	0.309
Fat intake (g/day)	0.086	0.562	-0.087	0.556
Protein intake (g/day)	-0.453	0.001*	0.428	0.002*
Physical activity (MET/min/week)	-0.156	0.274	0.129	0.372

*Statistically significant (p<0.05)
p-value for Spearman's rank correlation test

Table 3 show that among the dietary and physical activity variables analyzed, protein intake is the only factor significantly associated with both visceral fat percentage and muscle mass percentage. Specifically, protein intake has a moderate negative correlation with visceral fat percentage ($r = -0.453$, $p = 0.001$), indicating that higher protein consumption is linked to lower levels of visceral fat. Conversely, protein intake shows a moderate positive correlation with muscle mass percentage ($r = 0.428$, $p = 0.002$), suggesting that greater protein intake is associated with higher muscle mass. Other variables including carbohydrate intake, fat intake, and physical activity—do not show significant correlations with either visceral fat or muscle mass percentages (all p-values > 0.05).

Table 4 shows In the first multivariate model, which examines the simultaneous effects of carbohydrate, fat, and protein intake as well as physical activity on visceral fat percentage, only protein intake shows a statistically significant association ($B = -0.054$, $p = 0.028$). This negative coefficient indicates that higher protein intake is associated with a lower percentage of visceral fat. Carbohydrate intake, fat intake, and physical activity do not show significant relationships with visceral fat in this model. The overall explanatory power of the model is low ($R^2 = 0.130$), and the model is not statistically significant as a whole ($p = 0.221$). In the second model, which adds age, sex, weight, BMI, and socioeconomic factors, body mass index (BMI) and sex emerge as significant predictors of visceral fat percentage. BMI has a strong positive association ($B = 1.203$, $p < 0.001$), indicating that higher BMI is closely linked to higher visceral fat percentage. Female is also significant ($B = 1.482$, $p = 0.013$), suggesting a difference in visceral fat

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percentage between males and females. Other variables, including dietary intake, physical activity, age, weight, education, occupation, and monthly personal expenses, do not show significant associations in this expanded model.

Table 4. Multivariate Analysis of the Simultaneous Relationship between Independent Variables (Carbohydrate, Fat, and Protein Intake and Physical Activity) with Visceral fat Percentage

Variabel	Unstandarized Coefficient		Standarized Coefficient (Β)	t	p-value
	B	Std. Error			
Model 1					
Carbohydrate intake (g)	0.009	0.007	0.193	1.210	0.233
Fat intake (g)	0.008	0.033	0.037	0.252	0.802
Protein intake(g)	-0.054	0.024	-0.350	-2.273	0.028*
Physical activity (MET/min/week)	0.000	0.001	0.090	0.589	0.559
R Square	0.130				
F	1.500				
Sig. F	0.221				
Model 2					
Carbohydrate intake (g)	<0.001	0.001	0.008	0.259	0.797
Fat intake (g)	-0.012	0.006	-0.052	-1.782	0.084
Protein intake (g)	0.005	0.005	-0.033	0.967	0.340
Physical activity (MET/min/week)	<0.001	<0.001	0.052	1.463	0.153
Age	0.003	0.044	0.004	0.072	0.943
Sex	1.482	0.566	0.112	2.617	0.013*
Weight (kg)	0.006	0.042	0.014	0.148	0.883
Body Mass Indeks (kg/m^2)	1.203	0.114	0.989	10.598	<0.001*
Education history	0.540	0.373	0.044	1.448	0.157
Occupation	0.285	0.278	0.048	1.024	0.313
Montly personal expenses	-0.006	0.180	-0.001	-0.031	0.976
R square	0.976				
F	124.654				
Sig.	<0.001*				

*Statistically significant (p<0.05)

Table 5 indicate that, in the first model which examines the simultaneous effects of carbohydrate, fat, and protein intake as well as physical activity on muscle mass percentage, only protein intake shows a statistically significant positive association (B = 0.043, p = 0.046). The explanatory power of this model is low (R^2 = 0.106), and the overall model is not statistically significant (p = 0.330). In the second model, which includes additional variables such as age, sex, weight, BMI, education, occupation, and monthly personal expenses, several factors emerge as significant predictors of muscle mass percentage. Higher carbohydrate intake (B = 0.007, p = 0.028), lower physical activity (B = -0.001, p = 0.028), male (B = 6.041, p < 0.001), weight (B = 0.190, p = 0.042), and body mass index (BMI) (B = -1.021, p < 0.001) are all significantly associated with muscle mass percentage. Specifically, higher carbohydrate intake, being male, and higher body weight are associated with greater muscle mass percentage, while lower physical activity and lower BMI are associated with lower muscle mass percentage in this model. The second model has a much higher explanatory power (R^2 = 0.861) and is statistically significant overall (p < 0.001).

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Table 5. Multivariate Analysis of the Simultaneous Relationship between Independent Variables (Carbohydrate, Fat, and Protein Intake and Physical Activity) with Muscle Mass Percentage

Variable	Unstandarized Coefficient		Standarized Coefficient (B)	t	p-value
	B	Std. Error			
Model 1					
Carbohydrate intake (g)	<0.001	0.007	-0.005	-0.030	0.976
Fat intake (g)	0.001	0.029	0.007	0.048	0.962
Protein intake (g)	0.043	0.021	0.321	2.058	0.046*
Physical activity (MET/min/week)	<0.001	<0.001	-0.033	-0.215	0.831
R Square	0.106				
F	1.190				
Sig. F	0.330				
Model 2					
Carbohydrate intake (g)	0.007	0.003	0.171	2.294	0.028*
Fat intake (g)	0.003	0.014	0.013	0.186	0.854
Protein intake (g)	0.018	0.011	0.131	1.557	0.129
Physical activity (MET/min/week)	-0.001	<0.001	-0.200	-2.298	0.028*
Age	0.134	0.094	0.199	1.436	0.160
Sex	6.041	1.201	0.522	5.030	<0.001*
Weight	0.190	0.090	0.499	2.110	0.042*
Body Mass Index	-1.021	0.241	-0.961	-4.240	<0.001*
Education history	0.300	0.792	0.028	0.378	0.708
Occupation	-0.938	0.590	-0.182	-1.590	0.121
Montly personal expenses	-0.758	0.382	-0.152	-1.983	0.560
R square	0.861				
F	18.627				
Sig.	<0.001*				

*Statictically significant (p<0.05)

DISCUSSIONS

This study investigated the relationship between dietary intake and physical activity with visceral fat and muscle mass percentage in Indonesian adults. Our finding revealed both carbohydrate and fat intake not significant correlation with visceral fat consumtion similir with health Canadian adult found that individual with normal BMI tended to consume equal amounts of carbohydrate and fats compare to overweight or obese groups. The study suggests that people with normal weight consume more fat and cabohydrate, while obese individuals may reduce fat intake as part of weight management efforts [21]. Analysis bivariate of this study found that significant correlation on between protein intake with visceral fat and muscle mass percentage. Moon dan Koh [22] similarly reported that protein intake resulted in greater reductions in body weight and fat mass and maintenance muscle mass. This finding consistent with evidence that higher protein consumption promotes lean tissue synthesis while inhibiting visceral fat accumulation [23]. After adjusting for multiviariate analysis with cofounding factors, protein intake maintained a significant negative relationship with visceral fat percentage and BMI more directly and robustly associated with visceral fat accumulation than dietary or physical activity measures alone. This relationship is supported by multiple recent studies found a significant relationship between BMI and visceral fat across both males and females, with higher BMI strongly predicting increased visceral fat levels (p<0.001) [24][23]. This finding is also similar to multivariate analysis on muscle mass percentage protein intake became non-significant. Jeong, et al [26] study confirms

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that both sex and BMI are significant predictors of body composition, including muscle mass.

The present study identified a negative correlation between physical activity with visceral fat percentage (r = -0.156, p = 0.274) and positive correlation with muscle mass (r = 0.129, p = 0.372). These results align with existing regional research. Murbawani, et al. [6] similarly reported no significant correlation between physical activity, visceral fat, and muscle mass using BIA (r = 0.242, p = 0.078)(r = 0.176, p = 0.195). Clara, et al. [27] observed no statistically significant correlation between physical activity and visceral fat accumulation (p = 0.132) in the Palembang investigation Limbong & Elon reported no signifcant correlation between physical activity and muscle mass (p >0.05). However, these findings contrast with research conducted by Sasri, et al [28] here a significant negative correlation between physical activity and visceral fat was reported (r = -0.324, p = 0.008) and Gauvain [29] significant positive correlation between physical activity with muscle mass (r = 0.32, p = <0.05).

Multivariate analysis demonstrated that dietary intake and physical activity were not significant predictors of visceral fat percentage or muscle mass percentage. Similarly, after adjusting for confounding factors, dietary intake and physical activity remained non-significant in the model for visceral fat percentage. In contrast, in the multivariate analysis for muscle mass percentage, after adjustment for confounding factors, carbohydrate intake, physical activity, sex, BMI, and weight emerged as significant predictors. This aligns with findings from Nishikori & Fujita [30] study showing that after adjusting for BMI and sex, carbohydrate intake significantly predicted fat to muscle mass ratio (β = 0.004, p < 0.001).

The lack correlation between physical activity and visceral fat may stem from measurement error inherent in the IPAQ-SF. Limitation of IPAQ-SF are suboptimal reliability, overestimation bias, and poor responsiveness [31], [32], [33]. The observed lack of relationship between dietary patterns, particularly carbohydrate and fat consumption, could be due to inconsistencies inherent in self-reported dietary data, as intake was recorded only once on a single day. Cace-control design limits causal interence. Body composition was not assessed using a gold standard method such as dual-energy X-ray absorptiometry (DXA) or magnetic resonance imaging (MRI). Instead, more accessible but less precise methods were used, which may have introduced measurement variability and affected the accuracy of the results. Due to time constraints, it was not feasible to recall participants for repeated measurements or follow-up over a one-week period, which could have improved the reliability and validity of the dietary and body composition data collected. Practical implications of the research finding that protein intake can increase muscle mass and reduce visceral fat. For individuals aiming to optimize their physical health, these findings suggest that ensuring sufficient high-quality protein intake, alongside an active lifestyle, is a practical and effective strategy to increase muscle mass and decrease harmful abdominal fat that induces several diseases.

CONCLUSIONS

This study demonstrates a significant association between higher protein intake and lower visceral fat percentage, as well as increase muscle mass. BMI was identified as the strongest predictor for visceral fat percentage as well as muscle mass, whereas female was the strongest predictor for visceral fat and male for muscle mass. Encouraging adequate protein and carbohydrate consumption alongside regular physical activity may improve body composition and metabolic health. Furthermore, the findings underscore the need for accurate, repeated dietary and physical activity measurements in future research to minimize reporting bias. Longitudinal studies with larger samples and objective measures of dietary intake and physical activity are recommended.

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