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The relationship between fiber intake and fat composition and hormone profile in women with central obesity

Kaitan asupan serat dengan komposisi lemak dan profil hormon pada wanita obesitas sentral

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Abstract

Central obesity is characterized by increased visceral and subcutaneous fat and is associated with metabolic and hormonal disturbances in women. This study aimed to analyze the relationship between dietary fiber intake and visceral fat, subcutaneous fat, and sex hormone–binding globulin (SHBG) levels in women with central obesity. A cross-sectional study was conducted in the Kediri Raya region in August 2025. The sample consisted of 70 women aged 19–45 years with a waist circumference greater than 80 cm, selected through purposive and quota sampling methods. A Semi-Quantitative Food Frequency Questionnaire was used to assess fiber intake. Visceral and subcutaneous fat were measured using Bioimpedance Analysis, and SHBG levels were obtained from blood samples. Statistical analyses included Pearson's correlation, Fisher's exact test, and multivariate linear regression adjusted for energy and macronutrient intakes. The results showed that fiber intake was significantly associated only with age ($p= 0.026$), but not with BMI, visceral fat, subcutaneous fat, or SHBG ($p > 0.05$). Multivariate analysis indicated that the carbohydrate–fiber interaction was negatively associated with BMI ($p= 0.038$) and visceral fat ($p= 0.011$). Conversely, fat–fiber interactions were positively associated with BMI ($p= 0.008$), visceral fat ($p= 0.006$), and subcutaneous fat ($p= 0.035$). No significant association was found between fiber intake and SHBG levels ($p > 0.05$). In conclusion, fiber intake in interaction with macronutrients influenced BMI and body fat composition but did not affect SHBG levels, highlighting the role of nutrient interactions in shaping visceral and subcutaneous fat tissue.

Keywords: Dietary fiber, obesity abdominal, subcutaneous fat, sex hormone-binding globulin, visceral fat

Abstrak

Obesitas sentral ditandai oleh peningkatan lemak visceral dan subkutan yang berhubungan dengan gangguan metabolik dan hormonal pada perempuan. Penelitian ini bertujuan menganalisis hubungan asupan serat dengan lemak visceral, lemak subkutan, serta kadar *sex hormone-binding globulin* (SHBG) pada wanita obesitas sentral. Penelitian potong-lintang telah dilaksanakan di wilayah Kediri Raya pada Agustus 2025. Sampel yaitu 70 perempuan berusia 19–45 tahun dengan lingkar pinggang >80 cm, dipilih menggunakan purposive dan quota sampling. Asupan serat dinilai dengan Semi-Quantitative Food Frequency Questionnaire. Lemak visceral dan subkutan diukur menggunakan Bioimpedance Analysis, dan kadar SHBG diperoleh dari sampel darah. Analisis menggunakan uji Pearson, Fisher's exact, dan regresi linier multivariat dengan penyesuaian energi dan makronutrien. Hasil, menunjukkan bahwa asupan serat hanya berhubungan signifikan dengan usia ($p = 0.026$), namun tidak dengan IMT, lemak visceral, lemak subkutan, maupun SHBG ($p > 0.05$). Analisis multivariat menunjukkan bahwa interaksi karbohidrat terhadap serat berhubungan negatif dengan IMT ($p = 0.038$) dan lemak visceral ($p = 0.011$). Sebaliknya, interaksi lemak terhadap serat berhubungan positif dengan IMT ($p = 0.008$), lemak visceral ($p = 0.006$), dan lemak subkutan ($p = 0.035$). Tidak ditemukan hubungan signifikan antara asupan serat dan SHBG ($p > 0.05$). Kesimpulan, asupan serat dalam interaksi dengan makronutrien memengaruhi IMT dan komposisi lemak tubuh, namun tidak memengaruhi kadar SHBG. Dengan demikian identifikasi interaksi nutrisi berperan terhadap variasi lemak visceral dan subkutan.

Kata Kunci: Lemak visceral, lemak subkutan, obesitas abdominal, serat diet, sex hormone-binding globulin

Introduction

Obesity is a significant health issue worldwide. Central obesity is defined as the predominant buildup of adipose tissue in the abdominal area, assessed through waist circumference measurement (Islam et al., 2020). Abdominal or central obesity is characterized by the accumulation of fat in the belly area, comprising both visceral and subcutaneous fat (Alwash et al., 2021).

Central obesity elevates the risk of non-communicable diseases, such as type 2 diabetes, cardiovascular disease, osteoarthritis, and cancer (Wong et al., 2020). According to the World Health Organization (WHO), the prevalence of obe.sity among adults is 16% and is projected to rise to 24% by 2035 (Obesity and Overweight, 2024; World Obesity Atlas 2023, 2023). Based on the most recent national survey, women have a higher prevalence of central obesity than men (54%). (Kemenkes, 2023). The prevalence increased from 2013 to 2018, with central obesity rates of 26.6% and 31%, respectively (Kemenkes, 2018, 2023). In 2023, East Java recorded a notable 7.8% rise in obesity prevalence. This increase in prevalence is the most significant relative to other provinces on Java Island (Kemenkes, 2013, 2018). Riskesdas (2018) indicates that Kediri does not have the highest prevalence of obesity, although it ranks among the cities with an obesity prevalence exceeding the national average (Kemenkes, 2018).

Factors affecting the prevalence of central obesity often include sociodemographic variables (Getahun et al., 2023; Liu et al., 2024; Ntimana & Choma, 2023), behavior or lifestyle (Kerkadi et al., 2019), stress (Xiao et al., 2020), and genetic predisposition (Christiansen et al., 2023). The increase in adipose tissue in the abdominal region can alter hormonal signaling and interfere with the menstrual cycles of women of childbearing age. This syndrome frequently manifests in women diagnosed with Polycystic Ovary Syndrome (PCOS). The greater the accumulation of fat in the body, the higher the adiposity. The persistent increase in adiposity may elevate the production of Reactive Oxygen Species (ROS) and pro-inflammatory cytokines, thus impairing insulin signaling and causing insulin resistance (Ahmed et al., 2021; Masenga et al., 2023). Hyperinsulinemia suppresses the synthesis of insulin-like growth factor (IGF-1), consequently enhancing the production of theca cell androgens and diminishing the synthesis of sex hormone-binding globulin (SHBG), which leads to increased testosterone levels and worsens hyperandrogenism symptoms (Johnson et al., 2025; Khatun et al., 2024). Hyperandrogenism may result in anovulation, oligoamenorrhea, and infertility (Yusuf et al., 2023).

Additional research indicates that adult women are susceptible to central obesity owing to lifestyle variables, including insufficient physical exercise, contraceptive use, and low fiber intake (Handayani et al., 2025). WHO states that an individual is recommended to have adequate fruit and vegetable consumption if they ingest five servings per day for seven consecutive days. However, 95.4% of Indonesians aged 5 years and above have a significantly low intake of fruits and vegetables among this population (Kemenkes, 2018).

Dietary fiber is a frequently overlooked non-nutritional component of everyday living. Dietary fiber can diminish fat absorption in the body, enhance satiety, and augment insulin production with the assistance of gut bacteria (He et al., 2022). Sufficient daily fiber intake can improve nutritional status, including body weight and waist circumference (Bahreynian et al., 2018), potentially increasing SHBG levels and mitigating insulin resistance and PCOS. Nevertheless, limited research exists on this topic, prompting the conduct of this study. This study aimed to investigate the correlation between fiber consumption and visceral and subcutaneous fat consumption, as well as SHBG levels in women with central obesity.

Methods

This was an observational study with a cross-sectional design. The research population comprised women aged 19-45 years with waist circumferences above 80 cm, domiciled in the Kediri Raya region as of August 2025. This study was approved by the Kadiri University Research Ethics Commission (ethical clearance certificate number: 061/10/VI/EC/KEP/UNIK/2025). This study employs purposive and quota sampling techniques, whereby samples are collected based on the study's inclusion criteria, and the sampling process ceases upon reaching the minimum required sample size. The minimum sample size was determined using the Lemeshow formula:

$$n = \frac{Z_{\alpha}^{2}\ p\ (1-p)}{d^{2}}$$
$$= \frac{1.28^{2}\ .\ 0.3\ (1-0.3)}{0{,}01^{2}}$$
$$= \frac{1.63\ .\ 0.3\ .\ 0.7}{0{,}01}$$
$$= 34.2 \sim 35$$

Therefore, the minimum sample size for this investigation was 35 respondents. The study's inclusion criteria consisted of women aged 19 – 45 years, domiciled in Kediri Raya, having a waist circumference over 80 cm, and consenting to participate. This study examined independent and dependent variables, using fiber intake as the independent variable and visceral fat, subcutaneous fat, and SHBG profile as dependent variables.

Data on dietary fiber intake were obtained through interviews using the Semi-Quantitative Food Frequency Questionnaire (SQFFQ), which records the types, frequency, and quantity of food consumed over the preceding month. This questionnaire has been validated by prior research focused on evaluating fiber source intake, particularly from vegetables and fruits (Nursabrina, 2025). Central obesity was assessed by evaluating waist circumference and body fat composition, encompassing visceral and subcutaneous fat, measured using Bioimpedance Analysis (BIA). BIA has demonstrated validity and accuracy in assessing overweight and obese adults (Anwer et al., 2023). SHBG profile data were acquired from blood samples.

Respondents' personal data were processed by coding each answer, while the data on fiber intake, visceral fat, subcutaneous fat, and SHBG profile are presented as ratio data and were subjected to a normality test using the Kolmogorov-Smirnov test. The data were examined using univariate analysis, presented descriptively, and bivariate analysis using Pearson for numerical data and Fisher's Exact for categorical data. The data were further examined using multivariate linear regression. Confounding variables, including energy and macronutrient consumption (carbohydrate, protein, and fat), were managed in statistical analyses by including them as covariates.

Result and Discussion

This study was effectively carried out in the Kediri Raya region in August 2025, involving 70 female participants aged 19-45 years, each with a waist circumference exceeding 80 cm.

The majority of respondents who lived in urban area (85.7%) were employed in the private sector (65.7%) and had either a high school (37.1%) or master's degree (37.1%). The results of the univariate data analysis are presented in Table 1.

Table 1. Respondent's characteristics

Respondent's Characteristics	n	%
Domicile		
Urban	60	85.7
Rural	10	14.3
Education		
High School	26	37.1
Bachelor's Degree	18	25.7
Master's Degree	26	37.1
Occupation		
College student	22	31.4
Private employee	46	65.7
Others	2	2.9
Monthly income/ Monthly Allowance		

<IDR 500.000	4	5.7
IDR 500.000 - < IDR 1.000.000	8	11.4
IDR 1.000.00 - < IDR 2.500.000	18	25.7
IDR 2.500.000 - < IDR 5.000.000	34	48.6
IDR 5.000.000 - < IDR 10.000.000	6	8.6
Respondent's Characteristics	**Mean**	**SD**
Age (year)	28.83	8.46
BMI (kg/m^2)	27.87	5.33
Waist Circumference (WC/ cm)	91.17	8.76
Total fat (%)	34.50	4.17
Visceral fat	9.61	6.35
Subcutaneous fat	31.08	5.62
Fiber intake (g/day)	12.29	6.09
Energy intake (kkal/day)	1102.0	469.64
Protein intake (g/day)	79.67	41.12
Fat intake(g/day)	79.32	59.35
Carb intake (g/day)	171.75	106.38
SHBG profile (fmol/ml)	0.37	0.22

Variables, including the respondents' characteristics, were subjected to bivariate analysis. Bivariate analysis employed the Pearson correlation coefficient for numerical data and Fisher's exact test for categorical data. Table 2 displays the outcomes of bivariate tests for categorical data.

Table 2. Bivariate Analysis of Categoric Data

Variable	Category	Fiber intake		
		Moderate	Low	p-value
Domicile	Urban	2	58	1.000
	Rural	0	10	
Education	Hight School	0	26	1.000
	Bachelor's Degree	0	18	
	Master's Degree	2	24	
Occupation	College student	0	22	1.000
	Private employee	2	44	
	Others	0	2	
Monthly income/Monthly Allowance	<IDR 500.000	0	4	0.143
	IDR 500.000 - <IDR 1000.000	0	8	
	IDR 1.000.000-<Rp2.500.000	0	18	
	IDR 2.500.000-<IDR 5.000.000	0	34	
	IDR 5.000.000-<IDR 10.000.000	2	4	

Table 2 shows that fiber intake was not significantly correlated with domicile, education, occupation, or monthly income/monthly allowance (p > 0.05). The bivariate outcomes of the bivariate analysis of numerical data are displayed in Table 3.

Table 3. Bivariate Analysis of Numeric Data

Variables	p-value	Coefficient
Age (years)	0.026*	-0.0375
BMI (kg/m^2)	0.942	0.013
WC (cm)	0.882	-0.026
Total fat (%)	0.079	0.0301
Visceral fat	0.964	0.008
Subcutaneous fat (%)	0.231	0.208
SHBG (fmol/ml)	0.885	0.025

*Note: *significant for fiber intake (α < 0.05)*

Table 2 indicates that age was the only variable associated with fiber consumption (*p value* = 0.026). Limited prior research has examined the relationship between age and fiber consumption. Nonetheless, diminished fiber intake is more commonly observed in women and correlates with lower education and income levels (Fauziyana et al., 2022).

Subsequently, multivariate testing was performed by developing multiple models that correlated the consumption of these beverages with body composition and SHBG levels. The multivariate test analyzed five models, which are detailed in Table 4.

Table 4. Multivariate Analysis

	Model 1	Model 2	Model 3	Model 4	Model 5
p-value	0.088	0.211	0.036	0.136	0.361
R^2	0.156	0.121	0.187	0.139	0.08
Adjusted R^2	0.075	0.037	0.11	0.057	0.008
Variable	BMI (kg/m^2)	% Total Fat	Visceral Fat	Subcutaneous Fat	SHBG
Energy and Fat Intake Intake	-24.51 (p=0.003)*	-15.69 (p=0.017)*	-28.91 (p=0.003)*	-21.21 (p=0.015)*	-0.152 (p=0.118)
Carbohydrate and Energy Intake	10.69 (p=0.050)*	3.88 (p=0.367)	16.63 (p=0.010)*	3.55 (p=0.536)	0.039 (p=0.791)
Energy and Protein Intake	2.64 (p=0.10)	2.57 (p=0.047)*	2.25 (p=0.230)	3.24 (p=0.060)*	0.088 (0.192)
Fat and Fiber Intake	26.72 (p=0.008)*	16.36 (p=0.039)	32.42 (p=0.006)*	22.33 (p=0.035)*	-
Carbohydrate and Fiber Intake	-15.57 (p=0.038)*	-6.75 (p=0.255)	-22.57 (p=0.011)*	-7.74 (p=0.327)	0.045 (p=0.755)
Age	1.18 (p=0.09)	0.73 (p=0.198)	1.79 (p=0.033)	1.08 (p=0.155)	-0.10 (p=0.744)

According to Table 4, Model 3 is the superior model, as it exhibits the greatest adjusted R^2 value, indicating that this regression model accounts for 11% of the variance in visceral fat, with the remainder attributed to other factors. Model 1 shows the correlation between nutritional intake and BMI. The findings revealed that BMI was accounted for by 7.5% through the intake variables, with the remainder attributed to other factors. According to Model 1, each standard deviation increase in the energy × fat interaction correlated with a reduction in BMI of 24.51 units (p=0.003; CI -45.45, -10.47). The interplay between energy and fat intake consistently has a detrimental influence on many indicators of body fat intake, including the body fat percentage, visceral fat, and subcutaneous fat.

Body Mass Index (BMI) is a metric for assessing body composition based on weight and height (Hasibuan & A, 2021). This study demonstrated that elevated energy and fat consumption significantly adversely affected BMI, body fat percentage, visceral fat, and subcutaneous fat. Prior studies have demonstrated a notable weight-loss benefit resulting from an increase in fat consumption and a reduction in carbohydrate intake to meet daily energy needs. The objective is to achieve a state of ketosis in the body; hence, the designation of his regime as a ketogenic diet (McGaugh & Barthel, 2022). Low carbohydrate intake initiates gluconeogenesis and ketogenesis, resulting in the production of ketone bodies (Melyana et al., 2021). Fat intake encompasses both saturated and unsaturated fats, constituting 60% of the total requirements, whereas carbohydrate intake represents 5% (Markovikj et al., 2023). A high-fat, low-carbohydrate diet normally lowers visceral fat initially, followed by a reduction in subcutaneous fat due to sympathetic nerve activity (Melyana et al., 2021).

Similarly, the interaction between carbohydrate and fiber intake negatively influenced BMI, with each standard deviation increase resulting in a reduction of 15.57 BMI units (p=0.038; CI. -37.67, -3.49). This correlation consistently had a negative effect on visceral fat in Model 3. The high-carbohydrate and fiber diet principle corresponds with the Mediterranean diet, emphasizing fruits, vegetables, complex carbohydrates, unsaturated fats, and fish as protein sources. The Mediterranean diet is considered effective for weight loss, particularly in obese individuals (Guasch-Ferré & Willett, 2021).

The Mediterranean diet includes antioxidants and anti-inflammatory agents, such as phenolic compounds, which may reduce inflammation associated with obesity, where pro-inflammatory agents are generated by white adipose tissue (Dominguez et al., 2023).

Furthermore, Model 1 indicates that each 1 standard deviation increase in the interaction between calories and carbohydrates can elevate

BMI by 10.69 units ($p = 0.05$; CI 0.759, 23.83). This outcome is similarly clear in Model 3, in which visceral fat is the dependent variable. A meal rich in energy and carbohydrates can elevate both BMI and visceral fat, as surplus carbohydrate consumption is converted into lipids and deposited in the adipose tissue (Bernstein et al., 2022). Furthermore, elevated consumption of high-carbohydrate foods might enhance the synthesis of pro-inflammatory cytokines, such as IL-6 and myeloperoxidase (MPO), which act as predictive biomarkers for obesity, prediabetes, and cardiovascular disease (Antunes et al., 2020).

Interaction between fat and fiber intake demonstrated a positive effect, with each 1 standard deviation increase resulting in a BMI increase of 26.27 units ($p=0.008$; CI 2.60, 53.06). Model 3 consistently demonstrated a positive correlation between the fat and fiber intake combination and visceral fat. These findings contrast with those of other studies, which indicate that a substantial consumption of fat and fiber may facilitate weight reduction by enhancing the production of short-chain fatty acids and gut bacteria, in addition to elevating the body's basal metabolic rate (B. Wang et al., 2020). This study has not yet elucidated why high-fat and high-fiber consumption may elevate BMI and visceral fat in women with central obesity; thus, additional research is required to clinically assess the impact of high fat and fiber intake on these parameters.

This study indicates that there is no significant correlation between fiber intake and SHBG, implying that other factors, such as growth hormone levels, thyroid hormone levels, and liver cirrhosis, may affect SHBG levels (Szybiak-Skora et al., 2025). Moreover, SHBG levels are affected by ethnicity, chronic obstructive pulmonary disease, coronary heart disease, smoking behaviors (Wang, 2021), and oxidative stress levels (Sun et al., 2021). Consequently, future studies must address these confounding variables.

SHBG levels are affected by metabolic syndrome diseases, including obesity, anorexia, and insulin resistance, and can be modified by the consumption of calories, fat, fiber, and protein. A partial examination of nutritional components is necessary to evaluate their impact on SHBG levels (Brianso-Llort et al. 2024). Other studies have shown that fiber intake does not directly alter SHBG levels but is mediated by BMI; hence, fiber intake can influence BMI reduction, which in turn can affect SHBG levels (Luo & Lin, 2023).

The limitations of this study include several confounding factors that may disrupt data analysis outcomes, requiring additional research to gather information on variables such as stress, sleep quality, and physical exercise. A further limitation is that the data on food intake are susceptible to recollection and reporting biases. Moreover, anthropometric measurements do not directly indicate fat distribution; instead, they rely on scales and calculations, which may introduce bias. Consequently, the findings of this study require validation through additional research employing longitudinal or experimental methodologies.

Conclusion

In conclusion, a notable correlation exists between age and fiber intake; however, no significant association was observed between fiber intake and BMI, total body fat, visceral fat, or SHBG in the bivariate analysis. In the multivariate analysis, fiber intake was positively associated with BMI, visceral fat, and subcutaneous fat when analyzed alongside fat intake, but negatively correlated with BMI and visceral fat when analyzed alongside carbohydrate intake. No significant correlation was identified between fiber consumption and SHBG; thus, additional research is required to account for potential confounding variables, including hormone levels, thyroid hormones, liver cirrhosis, and other metabolic diseases, to achieve a more precise effect estimate.

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