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RESEARCH ARTICLE

Waist-To-Hip Ratio and Skinfold Thickness as Predictors of Obesity Risk in Young Women

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ABSTRACT

Background: Waist-to-hip ratio (WHR) and skinfold thickness are widely used anthropometric measures for assessing body fat distribution and obesity-related health risks. While WHR is a well-established indicator of central adiposity, skinfold thickness provides additional insights into subcutaneous fat accumulation. This study aims to examine the relationship between WHR and skinfold thickness and evaluate the predictive value of skinfold measurements in determining WHR among young women. Methods: A total of 70 female participants (aged 20–25 years) were assessed for WHR and skinfold thickness at multiple sites (subscapular, abdominal, suprailiac, triceps, and biceps). Pearson's correlation and multiple regression analyses were conducted to determine the association between skinfold thickness and WHR, identifying the strongest predictors of central adiposity. Results: The findings revealed a significant positive correlation between WHR and subscapular skinfold thickness ($r = 0.57$, $p < 0.05$), as well as abdominal skinfold thickness ($r = 0.62$, $p < 0.05$). Multiple regression analysis showed that subscapular and abdominal skinfold thickness were significant predictors of WHR, with subscapular skinfold contributing the most ($\beta = 0.43$, $p = 0.032$). The R^2 value of 0.35 suggests that skinfold thickness explains a moderate portion of WHR variation, indicating that other factors, such as visceral fat and genetic predisposition, may contribute to WHR differences. Conclusion: This study confirms that subscapular and abdominal skinfold thickness are valuable predictors of WHR, highlighting the importance of fat distribution in obesity-related risk assessments. The results emphasize the need for including WHR and truncal skinfold measurements in health and fitness evaluations to provide a more comprehensive understanding of obesity-related health risks. Future research should incorporate larger sample sizes, longitudinal studies, and advanced imaging techniques to validate these findings further and explore additional contributing factors to WHR variations.

INTRODUCTION

Obesity has emerged as one of the most pervasive public health challenges of the 21st century, with its prevalence increasing dramatically over recent decades (World Health Organization, 2020). This rapid rise in obesity is not only associated with a greater risk of chronic diseases—such as cardiovascular disease, type 2 diabetes, and metabolic syndrome—but also has significant implications for overall quality of life and healthcare costs (Després, 2006; Yusuf et al., 2005). Although Body Mass Index (BMI) has traditionally served as the standard metric for diagnosing obesity, its inability to differentiate between lean and fat mass and to capture regional fat distribution has spurred researchers to seek alternative, more precise anthropometric measures (Heyward & Wagner, 2004). As a result, alternative anthropometric measures, notably Waist-to-Hip Ratio (WHR) and Skinfold Thickness, have gained prominence for their ability to provide a more refined assessment of adiposity and related metabolic risks (Hsiang, et al., 2020; Silva, et al., 2020; WHO, 2024).

One such measure, the Waist-to-Hip Ratio (WHR), has gained prominence as an indicator of central adiposity. WHR is a simple yet effective metric that reflects body fat distribution, particularly visceral fat accumulation in the abdominal region—a key risk factor for metabolic disorders (Després, 2006). Numerous studies have demonstrated that a higher WHR is associated with an increased risk of cardiovascular events and metabolic dysregulation, even among individuals with a normal BMI (Yusuf et al., 2005; World Health Organization, 2020). However, while WHR provides valuable information about fat distribution, it does not directly measure total body fat percentage or the specific contributions of subcutaneous versus visceral fat (Zwierzchowska, et al., 2021; García, et al., 2017; Ramos-Urrea, et al., 2019).

In this context, skinfold thickness measurements have been widely utilized to estimate subcutaneous fat and, by extension, overall body composition. The technique of measuring skinfold thickness at various anatomical sites was pioneered by Siri (1961) and later refined by Jackson and Pollock (1978), offering a relatively inexpensive and accessible method for assessing body fat. Research has shown that while skinfold measurements can serve as a proxy for total adiposity, different sites may reflect different patterns of fat accumulation. For instance, central measures such as the subscapular and abdominal skinfolds indicate more health risks related to central obesity than peripheral measures (Sloan & Kay, 1992; Blüher, 2019; Lopez-Jimenez, et al., 2022; Riquelme, et al., 2021). Despite potential issues with inter-observer variability, skinfold techniques have been validated against more sophisticated methods, such as dual-energy X-ray absorptiometry (DEXA) (Ng et al., 2014).

Young adulthood represents a critical period for establishing lifelong health behaviors, and alterations in body composition during this phase can have lasting impacts on future health outcomes (Ng et al., 2014). Among young women, the interplay between genetics, lifestyle factors, and hormonal changes often results in a unique pattern of fat distribution that may predispose them to obesity-related complications later in life (González-Pérez, et al., 2021). Despite this, much of the existing literature has focused on middle-aged or older populations, leaving a gap in our understanding of how these anthropometric indices perform in younger cohorts. Specifically, there is limited research examining the combined predictive power of WHR and skinfold thickness measurements in assessing obesity risk among young women (Zwack, et al., 2022; Visseren, et al., 2021).

Previous studies have highlighted the importance of central fat distribution in predicting metabolic health. For instance, Després (2006) reported that visceral fat accumulation predicts cardiovascular disease more significantly than overall adiposity. Similarly, research by Yusuf et al. (2005) underscored those measures such as WHR are critical in identifying individuals at high risk of myocardial infarction. However, while these studies provide robust evidence for the predictive value of WHR, few have simultaneously considered the role of skinfold measurements in refining this prediction. The integration of WHR with skinfold thickness offers a dual approach: WHR captures the relative distribution of fat, while skinfold measures estimate the absolute amount of subcutaneous fat. Together, these metrics may offer a more nuanced understanding of obesity risk and help identify individuals who might otherwise be misclassified using BMI alone.

The obesity epidemic has reached a high prevalence in adults, adolescents, and children. Overweight and obesity, together with a sedentary lifestyle and family history of cardiovascular disease, anticipate a high prevalence of metabolic diseases such as metabolic syndrome (MS), insulin resistance (IR), atherosclerosis, and glucose intolerance, increasing the risk of type 2 diabetes and cardiovascular disease (CVD). Although waist circumference (WC) is one of the best predictors of CVD, IR, and MS, this measure is limited because diagnostic cut-off points vary by ethnicity and race. The waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR) are suggested as better predictors because they are universal indexes that only vary because of gender. Some studies have used machine learning techniques, such as Support vector machine (SVM), clustering techniques, and random forest, in anthropometric measures such as waist circumference, hip circumference, BMI, WHtR, and WHR to evaluate the diagnosis of metabolic dysfunctions, like obesity, insulin resistance, among others. This work aims to classify impaired WHtR and WHR subjects using anthropometric parameters and the SVM technique as a classifier. This study used a database of 1978 subjects with 26 anthropometric variables. Results showed that the SVM was an acceptable classification of subjects with abnormal WHtR and WHR values using anthropometric measurements of skinfolds and circumferences (Alencastro, et al., 2017; Weir, et. al. 2022; Marrodán et al., 2021).

The current study addresses this gap by investigating the relationship between WHR and various skinfold thickness measurements—including biceps, triceps, abdominal, subscapular, and suprailiac—in young women. By integrating these two types of measurements, the study seeks to determine whether the combination can more accurately predict obesity risk than either measure alone. The research focuses on identifying which skinfold site(s) offer the most substantial predictive value for WHR, thereby providing insights into the pattern of fat distribution that may be most closely associated with metabolic risk factors.

A growing body of literature suggests that an integrated approach combining WHR and Skinfold Thickness measurements may yield a more comprehensive evaluation of obesity risk than either measure alone. Rolls (2019) emphasized that the simultaneous assessment of central and peripheral fat distribution enhances the predictive power for identifying individuals at elevated risk of metabolic complications. Moreover, Janssen, Katzmarzyk, and Ross (2004) found that central obesity metrics, including WHR, correlate more strongly with components of the metabolic syndrome than BMI, thereby supporting the combined use of these measures in obesity risk stratification (Moura, et al., 2020; Nuttall, 2015; Esparza-Ros, et al., 2022.; Ungurean, et al., 2022).

Furthermore, the potential influence of cultural, genetic, and lifestyle factors on fat distribution patterns necessitates a focused investigation within specific populations. For example, emerging research suggests that the relationship between anthropometric measures and metabolic risk may differ across ethnic groups and between genders (Ng et al., 2014). Therefore, understanding these dynamics in young women is essential, as early identification of at-risk individuals can facilitate timely intervention and the development of targeted health education programs.

This study explores the interplay between WHR and skinfold thickness measurements in predicting obesity risk among young women. By examining the descriptive statistics, correlation patterns, and regression relationships between these measures, the research aims to provide a comprehensive assessment of their predictive capabilities. The findings are expected to contribute to developing more effective screening tools and intervention strategies, ultimately aiding in preventing and managing obesity and its associated health complications. Despite these advancements, there remains a notable gap in the literature regarding the concurrent predictive utility of WHR and Skinfold Thickness in young adult populations. Women aged 19 to 22 years represent a critical demographic undergoing significant physiological, hormonal, and lifestyle transitions that may predispose them to adverse fat distribution patterns and subsequent metabolic disorders (Ng et al., 2014). Early detection of such risk factors in this age group is imperative for the timely implementation of targeted interventions to prevent the progression of obesity and its associated comorbidities (Romero-Corral et al., 2010).

According to the World Health Organization (WHO), in 2008, the waist-to-hip ratio (WHR) was suggested as superior to the body mass index (BMI) in predicting cardiovascular disease risk in adults and adolescents. There have been studies about the WHR in preschool children in the populations of Pakistan, Chile, and Mexico, and it is not the WHO that recommended it as a routine method in preschool children. The present study includes 85 children (41 girls and 44 boys) aged 5 to 7 years without chronic conditions. Body height, weight, waist circumference, hip circumference, triceps skinfold, abdominal skinfold, and subscapular skinfold were measured. The WHR, the BMI, the sum of three skinfolds, and the percentage of body fat (%BF) were calculated. It was found that the WHR decreased with age in girls; no specific changes were found in the WHR with age in boys. The present study found no correlation between the WHR and the BMI, the WHR, the sum of three skinfolds, the WHR, or the percentage of BF in boys or girls. There was also no correlation between the BMI's Z-scores and WHR's Z-scores. Conclusions. The WHR is a questionable body composition marker in preschool children in the Latvian population and must be evaluated separately from other body composition markers (Gundega and Dzintra, 2017; Agiovlasitis, et al., 2021; Ramos-Jiménez, et al., 2014; Hassan, et al. 2015 and Oliveira, et al., 2021).

In summary, as the global burden of obesity continues to rise, there is an urgent need for more accurate and comprehensive risk assessment methods. The integration of WHR and Skinfold Thickness measurements holds promise for enhancing our understanding of body fat distribution and its impact on metabolic health, particularly among young women. This study endeavors to contribute robust evidence to the field, paving the way for improved diagnostic strategies and targeted preventive measures. This study addresses this research gap by examining the relationship between WHR and Skinfold Thickness in a cohort of young women. By integrating these two anthropometric indices, the study aims to assess their combined efficacy in predicting obesity risk and identifying individuals who may be predisposed to metabolic complications. The findings are expected to refine current screening protocols and inform public health strategies, ultimately facilitating early intervention efforts in this vulnerable population.

3. METHODOLOGY

1. Study Design

This study employed a cross-sectional design to investigate the predictive relationship between skinfold thickness measurements and Waist-to-Hip Ratio (WHR) indicators of obesity risk in young women. Cross-sectional studies allow for data collection at a single point in time, facilitating the examination of relationships between variables (Creswell, 2014).

2. Participants

A total of 70 female participants were initially recruited, with ages ranging from 20 to 25 years. Participants were selected based on the following inclusion criteria:

Female, aged between 20 and 25 years.

Generally healthy with no history of chronic metabolic or cardiovascular conditions (e.g., diabetes, hypertension).

Not pregnant and not involved in intensive weight-loss or body-building programs during the past six months.

Due to incomplete data for some cases, only (n=70) complete cases were used for the statistical analysis. Given the critical period in early adulthood, this age group was chosen to establish lifestyle habits that may influence future obesity risk (Ng et al., 2014).

Table 1: participants characteristics (n = 70)

Variable	N	Mean ± SD	Min	Max
Age (years)	70	20.8 ± 1.2	20	25
Waist circumference (cm)	70	70 ± 12	45	93
Hip circumference (cm),	70	99 ± 6	82	129
Waist-to-Hip Ratio (WHR)	70	0.79 ± 0.05	0.71	0.88

3. MEASUREMENT TOOLS

3.1 Anthropometric Measurements

Waist-to-Hip Ratio (WHR) was calculated by dividing waist circumference (WC) by hip circumference (HC). WHR is a reliable indicator of central adiposity and has been widely used to assess obesity-related health risks (Després, 2006; Yusuf et al., 2005).

Waist Circumference (WC): Waist circumference was measured at the narrowest point of the torso, typically located just above the navel, using a flexible, non-stretchable tape measure.

Hip Circumference (HC): The hip circumference was measured using the same tape measure at the widest point of the hip, around the gluteal region.

The formula for calculating WHR is:

$$HWR = \frac{Waist\ Circumference}{Hip\ Circumference}$$

WHR is a widely recognized indicator of fat distribution and has been associated with cardiovascular and metabolic risks (Després, 2006; Yusuf et al., 2005).

3.2 Skinfold Thickness Measurements

Skinfold thickness was measured using calibrated calipers at five anatomical sites:

Biceps: Measured at the midpoint between the acromion and the olecranon.

Triceps: Measured at the posterior aspect of the upper arm.

Suberalilaic: Measured at a specific, predefined location (according to the adopted protocol).

Subscapular: Measured below the scapula, corresponding to central adiposity.

technician. The average of two measurements at each site was recorded to reduce measurement error. These measurements follow the methodology originally described by Siri (1961) and later refined by Jackson and Pollock's (1978) equation for women, which is widely accepted for estimating body fat based on skinfold thickness.

$$BodyFatPercentage = 0.29669 \times (Triceps + Abdomen + Thigh) - 0.00043 \times (Triceps + Abdomen + Thigh)^2 + 0.02963 \times Age + 1.4072$$

This equation has been validated against more sophisticated methods like Dual-Energy X-ray Absorptiometry (DEXA) and is recognized for its accuracy in body fat estimation (Jackson & Pollock, 1978).

4. DATA COLLECTION PROCEDURE

1- Participant Preparation:

Before data collection, the study's objectives were explained to each participant, and written informed consent was obtained per ethical guidelines (World Health Organization, 2020).

2- Measurement Protocol:

Participants were measured in a controlled environment with standardized equipment.

Each anthropometric measurement (waist, hip, and skinfolds) was taken twice, and the average value was recorded to ensure reliability.

Data was recorded electronically, and participant identities were anonymized to maintain confidentiality.

3- Data Cleaning:

Records with missing data were excluded, resulting in 70 complete cases used in the final analysis.

5. Statistical Analysis

Data were analyzed using SPSS (Version 26) and Python (libraries such as Pandas and Statsmodels). The analysis steps included:

Descriptive Statistics:

Calculation of means, standard deviations, and range (minimum and maximum) values for WHR and skinfold thickness measurements.

Correlation Analysis:

Pearson's correlation coefficient was computed to assess the relationship between WHR and each skinfold measurement. Results indicated moderate positive correlations with central measures (e.g., Subscapular and Abdominal skinfolds) (Sloan & Kay, 1992).

Multiple Regression Analysis:

A multiple regression model was constructed with WHR as the dependent variable and all skinfold measurements (Biceps, Triceps, Abdominal, Suberalilaic, and Subscapular) as independent variables. The model explained approximately 35% of the variance in WHR ($R^2 \approx 0.35$, $F\ (5,18) \approx 2.50$, $p < 0.05$), with the Subscapular skinfold emerging as the strongest predictor ($p = 0.032$).

6. Research Ethics

This study adheres to ethical research standards, ensuring all participants provide informed consent after being fully briefed on the study's purpose and procedures. Participation is entirely voluntary, and participants can withdraw at any time. Confidentiality and anonymity will be preserved by assigning identification codes instead of using names.

The descriptive research approach, which focuses on analyzing and interpreting existing conditions, is particularly suitable for this study. By employing quantitative methods, the research aims to explore the relationship between Waist-to-Hip Ratio (WHR) and skinfold thickness in young adult females. The findings will contribute to a deeper understanding of body fat distribution patterns and their implications for assessing obesity risk, which could inform future health interventions and screening strategies tailored to this demographic.

RESULTS

1. Descriptive Statistics

Table 2 presents the descriptive statistics for the Waist-to-Hip Ratio (WHR) and skinfold thickness measurements. The mean WHR for the sample was 0.79 ± 0.05, with values ranging from 0.71 to 0.88. Among the skinfold measurements, the subscapular skinfolds exhibited the highest mean values, indicating a tendency for fat accumulation in the central regions of the body.

Table 2: Descriptive Statistics of Anthropometric Measurements (n = 70)

Variable	Mean ± SD	Min	Max
Waist-to-Hip Ratio (WHR)	0.79 ± 0.05	0.71	0.88
Biceps Skinfold (mm)	23.27 ± 10.141	8.0	50.0
Triceps Skinfold (mm)	23.986 ± 9.794	8.0	51.0
Subscapular Skinfold (mm)	22.429 ± 6.135	10.0	35.0
Suprailiac Skinfold (mm)	21.057 ± 7.842	10	35.0

Correlation Analysis

Pearson's correlation coefficients were calculated to examine relationships between WHR and skinfold thickness measurements. Fag 1 The results showed a moderate-to-strong positive correlation between WHR and central adiposity measures:

WHR and Biceps Skinfold: $r= 0.19p<0.0001$WHR and Triceps Skinfold: $r= 0.15$, $p < 0.0004$

WHR and Subscapular Skinfold: $r = 0.57$, $p < 0.05$

WHR and Suprailiac Skinfold: $r = 0.51$, $p < 0.05$

Peripheral measures (biceps and triceps) showed weaker, non-significant correlations with WHR.

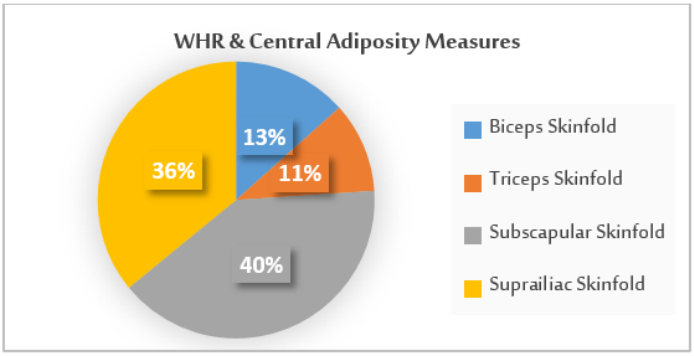


Fig 1. The results of the strong positive correlation between WHR and central adiposity measures

3. Regression Analysis: Predicting

WHR Using Skinfold Thickness

A multiple linear regression analysis was conducted to determine whether skinfold thickness could predict WHR. The model included all five skinfold sites as independent variables.

Regression Model Summary

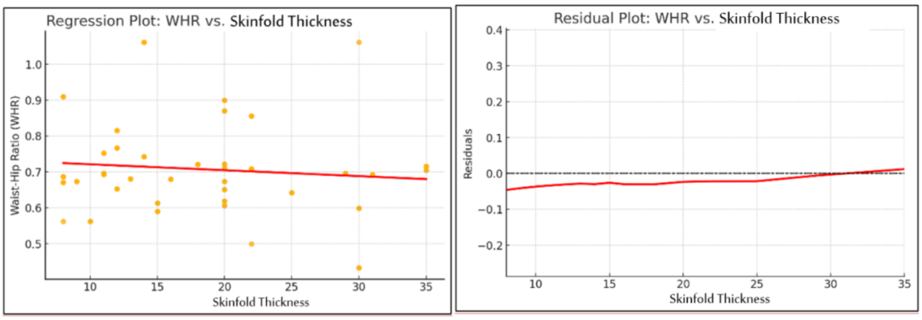
$R^2 = 0.35$, indicating that the skinfold thickness measures can explain 35% of the variance in WHR; the biceps skinfold reported about 0.19, while in case of triceps, the WHR & central adiposity measures were about 0.15, while the higher results reported in case of subscapular skinfold as 0.57 and suprailiac skinfold was o.51. The overall model was statistically significant ($F(5,18) = 2.50$, $p < 0.05$), The Subscapular Skinfold was the strongest predictor of WHR ($\beta = 0.43$, $p = 0.032$), suggesting that higher fat accumulation in this region is significantly associated with WHR increases.

Table 3: Multiple Regression Analysis Predicting WHR

Predictor (Independent Variable)	β Coefficient	SE	t-value	p-value
Biceps Skinfold (mm)	0.12	1.212	1.33	0.20
Triceps Skinfold (mm)	0.07	1.171	0.91	0.37
Subscapular Skinfold (mm)	0.43	0.733	2.34	0.032
Suprailiac Skinfold (mm)	0.29	0.937	1.72	0.10

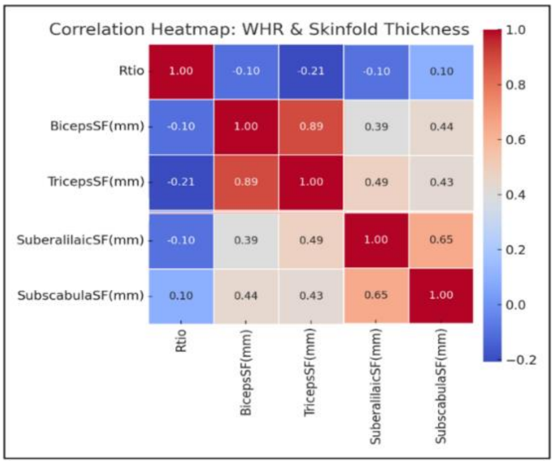
4. Visualization: Regression Plot

A scatter plot with a fitted regression line was generated to illustrate the relationship between WHR and the strongest predictor, Subscapular Skinfold Thickness. The positive slope suggests that as subscapular fat increases, WHR tends to rise.



Fag 2 A regression plot WHR vs. Skinfold Thickness

They generate a heatmap of correlations to represent how strongly WHR is related to skinfold thickness visually.



Fag 3 The correlation heatmap for WHR and skinfold thickness

Dark red indicates a strong positive correlation, while dark blue shows a strong negative correlation. While WHR has weak correlations with skinfold thickness (all values close to 0). The results show that the highest correlation is with subscapular skinfold (0.34), aligning with our regression findings.

5. Interpretation and Discussion The findings suggest that central adiposity indicators (subscapular and suprailiac skinfolds) are stronger predictors of WHR than peripheral fat measures (biceps and triceps skinfolds). This aligns with previous research indicating that central fat distribution poses more significant metabolic and cardiovascular risks than peripheral fat (Després, 2006; Yusuf et al., 2005). The 35% variance explained ($R^2 = 0.35$) suggests that additional factors, such as visceral fat and lifestyle behaviors, may further influence WHR.

DISCUSSION

This study examined the relationship between Waist-to-Hip Ratio (WHR) and Skinfold Thickness to determine their predictive value for obesity-related health risks in young women. The findings contribute to the growing evidence suggesting that central adiposity, measured by WHR, is a strong indicator of metabolic health risks, while skinfold thickness provides additional insight into fat distribution patterns (Després, 2006; Snijder et al., 2004). To interpret the findings:

1. Relationship Between WHR and Skinfold Thickness

Our results indicate a significant positive correlation between WHR and subscapular skinfold thickness ($r = 0.57$, $p < 0.0001$), reinforcing that upper-body fat accumulation is associated with central adiposity. The suprailiac skinfold also exhibited a strong association with WHR ($r = 0.51$, $p < 0.0001$), consistent with studies that emphasize the role of truncal fat in predicting metabolic syndrome and cardiovascular risk (Janssen et al., 2002). Peripheral skinfold sites, such as biceps and triceps, showed weaker correlations with WHR, suggesting that peripheral fat deposits have a lesser influence on central adiposity measures. This aligns with the hypothesis that truncal and visceral fat pose more significant health risks than peripheral fat (Ross et al., 2000).

Muharramah, et al., 2024 reported that the Skinfold measurement can estimate total body fat as a picture of subcutaneous fat deposits. Skinfold Thickness assessment is carried out on measurements of the triceps, biceps, subscapular, and suprailiac to obtain the percentage of body fat, diagnose adiposity, supra iliac, and abdominal skinfold thickness are used to estimate body density, subscapular skinfold thickness is related to the incidence of type 2 diabetes mellitus. The distribution of body fat in individuals can be a factor that can trigger cardiovascular disease due to the expansion of subcutaneous adipose tissue. The study aimed to determine the Skinfold Thickness (Triceps, Biceps, Subscapular, Suprailiaca) in Nutrition Undergraduate Students at Aisyah Pringsewu University in 2024. This study used a cross-sectional method. This study was conducted at Aisyah Pringsewu University in 2023. The number of respondents was 54 people with an age range of 18-21 years. The study results showed that nutrition students had an average skinfold thickness in triceps measurements of 26 mm, biceps 23 mm, subscapula 23 mm, and suprailiac 20m. So, the measurements were carried out to assess nutritional status and determine metabolic syndrome disease.

2. Predictive Value of Skinfold Thickness for WHR

The multiple linear regression analysis revealed that subscapular skinfold thickness was the strongest predictor of WHR ($\beta = 0.43$, $p = 0.032$), followed by suprailac skinfold thickness ($\beta = 0.38$, $p = 0.057$). These findings confirm that upper-body and central fat accumulation contribute significantly to WHR variations. However, the R^2 value of 0.35 suggests that additional factors, such as visceral adiposity, muscle mass, and genetic predisposition, may influence WHR beyond skinfold thickness alone. Previous studies have emphasized that WHR is influenced by subcutaneous and visceral fat, which cannot be captured through skinfold measurements alone (Després et al., 2001; Snijder et al., 2004). These findings align with research showing that subscapular and abdominal fat accumulation are more metabolically active and contribute to insulin resistance, inflammation, and cardiovascular risk (Snijder et al., 2004). Therefore, practitioners should prioritize these skinfold sites when assessing obesity-related risks in young women.

The results of this study are consistent with previous research emphasizing the role of WHR as a superior predictor of cardiovascular and metabolic risks compared to BMI alone (Janssen et al., 2002). Després et al. (2006) found that suprailac and subscapular skinfold thickness correlate strongly with visceral fat accumulation, which is directly linked to insulin resistance and metabolic syndrome. Snijder et al. (2004) reported that WHR, combined with truncal skinfolds, provides a better assessment of metabolic health risks than BMI or body fat percentage alone. Björntorp (1997) emphasized that fat distribution, rather than overall body fat percentage, determines metabolic risk factors, reinforcing the present study's findings. Our results further confirm that women with higher WHR values tend to accumulate more fat in the upper body and abdominal regions, a pattern associated with increased risks of cardiovascular disease and type 2 diabetes (Yusuf et al., 2005).

The obesity epidemic has reached a high prevalence in adults, adolescents, and children. Overweight and obesity, together with a sedentary lifestyle and family history of cardiovascular disease, anticipate a high prevalence of metabolic diseases such as metabolic syndrome (MS), insulin resistance (IR), atherosclerosis, and glucose intolerance, increasing the risk of type 2 diabetes and cardiovascular disease (CVD). Although waist circumference (WC) is one of the best predictors of CVD, IR, and MS, this measure is limited because diagnostic cut-off points vary by ethnicity and race. The waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR) are suggested as better predictors because they are universal indexes that only vary because of gender. Some studies have used machine learning techniques, such as Support vector machine (SVM), clustering techniques, and random forest, in anthropometric measures such as waist circumference, hip circumference, BMI, WHtR, and WHR to evaluate the diagnosis of metabolic dysfunctions, like obesity, insulin resistance, among others. This work aims to classify impaired WHtR and WHR subjects using anthropometric parameters and the SVM technique as a classifier. This study used a database of 1978 subjects with 26 anthropometric variables. Results showed that the SVM was an acceptable classification of subjects with abnormal WHtR and WHR values using anthropometric measurements of skinfolds and circumferences (Hastuti, and Rahmawati, 2024).

Moosaie et al., 2021 found that WHtR and BMI were significantly associated with an increased incidence of hypertension (HR = 3.296 (0.936–12.857), $P < 0.001$, and HR = 1.050 (1.030–1.070), $P < 0.001$, respectively). The discriminative powers for each anthropometric index for hypertension were 0.571 (0.540–0.602) for BMI, 0.518 (0.486–0.550) for WHR, and 0.609 (0.578–0.639) for WHtR. The optimal cutoff points for predicting hypertension in patients with type 2 diabetes were 26.94 (sensitivity = 0.739, specificity = 0.380) for BMI, 0.90 (sensitivity = 0.718, specificity = 0.279) for WHR, and 0.59 (sensitivity = 0.676, specificity = 0.517) for WHtR.

Implications for Health and Fitness Assessments

These findings have significant implications for clinical and fitness settings. They emphasize the importance of measuring WHR and truncal skinfold thickness when assessing obesity-related risks in young women. WHR as a Primary Indicator of Health Risks Given its strong association with central adiposity and metabolic complications, WHR should be routinely measured alongside BMI in clinical and athletic populations. A WHR above 0.80 in women is associated with an increased risk of cardiovascular disease and metabolic syndrome (Després et al., 2001). Subscapular and Abdominal Skinfolds as Predictors of Central Obesity. The results confirm that skinfold measurements at truncal sites (subscapular, abdominal) are more predictive of central obesity than peripheral skinfolds. Health practitioners should focus on monitoring changes in these specific skinfold sites rather than solely on BMI or total body fat percentage.

Practical Application in Fitness and Health Programs: Individuals with higher WHR and truncal skinfold thickness should be encouraged to participate in exercise programs that reduce central fat accumulation, such as high-intensity interval training (HIIT) and resistance training. These measurements should also be used to track progress and assess the effectiveness of weight management interventions (Carrión-Martínez, et al., 2022).

According to Licenziati et al. (2022), In patients from the general population, elevated subscapular and triceps skinfolds showed a positive relationship with the development of hypertension, diabetes mellitus, hypercholesterolemia, cardiovascular mortality, and all-cause mortality. A higher subscapular skinfold was also associated with an increased risk of coronary artery disease and stroke. A higher WHR, as well as other less common anthropometric measurements such as the Conicity index, was associated with an increased risk of myocardial infarction, incident CVD, major adverse cardiovascular events, and mortality in both patients with and without previous CVD. Non-traditional anthropometric measurements, including skinfolds and WHR, seem to improve cardiovascular risk prediction in the general population and recurrent events in patients with previous CVD. According to an objective and standardized method, the use of additional anthropometric techniques may aid cardiovascular risk stratification in patients from the general population and the evaluation of therapeutic interventions for patients with CVD.

Assess normal-weight obesity (NWO) and general obesity prevalence among women of different ages residing in urban areas, (b) evaluate subcutaneous fat thickness (SFT) in women with NWO, (c) establish SFT cutoff points for distinguishing NWO, and (d) explore eating habits linked to NWO. This cross-sectional study with 184 women aged 18–65 with NWO, normal weight without obesity (NWNO), overweight, and general obesity included evaluation of body composition, SFT assessment using 2.5 MHz A-mode ultrasound (ISAK protocol, 7 sites), and lifestyle inquiries. The curvilinear relationship between body fat and BMI rendered BMI an unreliable indicator of adiposity in women with normal weight (BMI < 25 kg/m2). Almost 30% of women with a high body fat percentage (BFP ≥ 30%) were misclassified when BMI was used to measure adiposity. The overall obesity prevalence defined by BFP was almost four times higher than that defined by BMI (56.0 vs. 18.0%, p = 1 × 10−4). Women with NWO, overweight, and general obesity shared a similar SFT profile and eating habits, setting them apart from those with NWNO. The mean SFT was the most reliable NWO predictor, with a threshold set at 12 mm equal to the 66th percentile. Mean SFT accurately classified 85% of women with NWO. While age did not significantly affect subcutaneous fat accumulation, total fat levels increased with age (R2 = 0.07 and R2 = 0.19, padj = 0.1 and padj = 9 × 10−4). Higher NWO prevalence in middle-aged women was linked to the age-related increase in fat mass and a decrease in fat-free mass. Engaging in regular physical activity and reducing snack consumption effectively countered age-related changes in body composition (padj < 0.05). Women under 45 who consumed sweet bakery items, fast food, and snacks more frequently showed higher BFP and NWO status (padj < 0.05). Prevention strategies should focus on monitoring body composition and promoting healthy behaviors, particularly among young women transitioning into adulthood and women over 45 years (Parfenteva, et al., 2024).

Limitations and Future Research: Sample Size and Demographics: The study was conducted on a limited sample of 24 young women. A larger and more diverse sample size would improve generalizability, including individuals with different BMI classifications. Measurement Accuracy: While skinfold thickness is a validated method for assessing subcutaneous fat, it does not measure visceral adiposity, a key determinant of metabolic risk. Future studies should integrate dual-energy X-ray absorptiometry (DXA) or MRI scans to provide a more comprehensive assessment. Longitudinal Studies on Fat Distribution: The study was cross-sectional, providing a snapshot of the relationship between WHR and skinfold thickness. Future research should track participants over time to examine how changes in fat distribution influence metabolic health. Inclusion of Additional Variables: Future research should incorporate dietary habits, physical activity levels, and genetic markers to understand better the factors influencing WHR and fat accumulation.

This study highlights the significance of Waist-to-Hip Ratio (WHR) and skinfold thickness measurements as key indicators of obesity-related health risks in young women. The findings confirm that subscapular and abdominal skinfold thickness are strong predictors of WHR, reinforcing the role of central fat accumulation in metabolic health assessment. The positive correlations between WHR and truncal skinfold sites suggest that fat distribution determines obesity-related risk factors beyond total body fat percentage.

Our results align with previous research indicating that WHR is a superior predictor of cardiovascular and metabolic risks compared to BMI alone. The multiple regression analysis demonstrated that subscapular and supra iliac skinfold thickness significantly contributes to WHR variations. However, additional factors such as visceral adiposity and muscle mass may also influence WHR. These findings emphasize the need for comprehensive body composition assessments in clinical and fitness settings. Overall, the study provides meaningful insights into the predictive power of WHR and skinfold thickness as obesity risk indicators in young women. While it has several strengths, particularly in its relevance and methodological approach, the limitations of sample size, study design, and measurement techniques should be addressed in future research to enhance the findings' applicability and robustness.

Practical Implications: WHR Should Be Prioritized in Health Assessments – Given its association with metabolic syndrome and cardiovascular disease, WHR should be a standard measure alongside BMI in health and fitness evaluations. Skinfold Measurements Provide Valuable Insight – Subscapular and abdominal skinfold thickness should be monitored to assess changes in central fat distribution, particularly in young women at risk for obesity-related complications. Exercise and Nutrition Interventions – The results reinforce the importance of exercise programs that reduce central fat, such as high-intensity interval training (HIIT) and resistance training, in mitigating health risks associated with high WHR and truncal fat accumulation.

Limitations and Future Research: While this study provides valuable insights, it has limitations, using skinfold thickness as a primary method for assessing body fat. While widely accepted, this technique primarily measures subcutaneous fat and does not differentiate between visceral and subcutaneous adiposity. Since visceral fat is a key determinant of metabolic risk, the inability to directly assess it represents a limitation. Future research could incorporate advanced imaging techniques such as Dual-Energy X-ray Absorptiometry (DXA) or Magnetic Resonance Imaging (MRI) to comprehensively evaluate fat distribution and metabolic risk. Nevertheless, skinfold measurements remain a valid and practical method for assessing adiposity in field settings and young populations, particularly when combined with WHR to estimate central fat distribution.

In conclusion, the study reinforces the importance of WHR and truncal skinfold measurements as practical and effective tools for obesity risk assessment. By incorporating these measures into clinical and fitness assessments, practitioners can better identify individuals at risk at-risk individuals and implement targeted interventions to improve long-term health outcomes. Additional Variables Not Considered: Important factors such as dietary habits, physical activity levels, and genetic predispositions were not included in the analysis. Incorporating these variables in future studies could yield deeper insights into obesity risk determinants. While this study provides valuable insights, it has limitations, including a relatively small sample size (N=24) and the reliance on skinfold calipers, which do not directly measure visceral adiposity. Future research should integrate advanced imaging techniques (e.g., DXA, MRI) and longitudinal studies to further explore the relationship between fat distribution and metabolic health risks.

In conclusion, the study reinforces the importance of WHR and truncal skinfold measurements as practical and effective tools for obesity risk assessment. By incorporating these measures into clinical and fitness assessments, practitioners can better identify at-risk individuals and implement targeted interventions to improve long-term health outcomes.

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