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Correlation of Hemoglobin, Uric Acid, and Anthropometric as Predictor Parameters in Subcutaneous Fat Deposition

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Abstract. *Subcutaneous fat deposition is a key factor influencing overall health, playing a significant role in metabolic regulation, energy balance, and the risk of chronic diseases such as obesity and cardiovascular conditions. Understanding and accurately predicting subcutaneous fat accumulation is critical for early intervention and effective management of these health risks. This study aims to analyze the correlation between hemoglobin levels, uric acid, and anthropometric parameters as predictors of subcutaneous fat deposition in elderly individuals. A cross-sectional study was conducted on 32 elderly participants at St. Asisi Church. Anthropometric measurements, including body weight, height, muscle composition, and circumferences, were assessed using OMRON Body Composition Monitor HBF-375, elastic tape and GEA Medical HT721. Biochemical tests for hemoglobin and uric acid levels were performed using Fora 6 Plus. Spearman correlation analysis was used to evaluate the relationship between these variables and subcutaneous fat deposition. Body weight, upper arm circumference, abdominal circumference, and calf circumference showed strong positive correlations with subcutaneous fat (r>0.9, p<0.001). Skeletal muscle percentage exhibited a negative correlation with fat accumulation. Hemoglobin and uric acid levels had weaker correlations, suggesting more complex metabolic interactions. Anthropometric parameters serve as strong predictors of subcutaneous fat deposition in elderly individuals, while hemoglobin and uric acid levels show limited predictive capability.*

Keywords: *Anthropometry, Uric Acid, Hemoglobin, Metabolic Health, Subcutaneous Fat,*

Abstrak. Penumpukan lemak subkutan merupakan faktor kunci yang memengaruhi kesehatan secara keseluruhan, memainkan peran penting dalam regulasi metabolisme, keseimbangan energi, dan risiko penyakit kronis seperti obesitas dan kondisi kardiovaskular. Memahami dan memprediksi secara akurat akumulasi lemak subkutan sangat penting untuk intervensi dini dan manajemen risiko kesehatan yang efektif. Penelitian ini bertujuan untuk menganalisis korelasi antara kadar hemoglobin, asam urat, dan parameter antropometri sebagai prediktor penumpukan lemak subkutan pada individu lanjut usia. Sebuah penelitian cross-sectional dilakukan pada 32 peserta lanjut usia di Gereja St. Asisi. Pengukuran antropometri, termasuk berat badan, tinggi badan, komposisi otot, dan lingkar, dinilai menggunakan OMRON Body Composition Monitor HBF-375, pita elastis, dan GEA Medical HT721. Uji biokimia untuk kadar hemoglobin dan asam urat dilakukan menggunakan Fora 6 Plus. Analisis korelasi Spearman digunakan untuk mengevaluasi hubungan antara variabel-variabel ini dan penumpukan lemak subkutan. Berat badan, lingkar lengan atas, lingkar perut, dan lingkar betis menunjukkan korelasi positif yang kuat dengan lemak subkutan (r>0,9, p<0,001). Persentase otot rangka menunjukkan korelasi negatif dengan akumulasi lemak. Kadar hemoglobin dan asam urat memiliki korelasi yang lebih lemah, yang menunjukkan interaksi metabolik yang lebih kompleks. Parameter antropometri berfungsi sebagai prediktor kuat pengendapan lemak subkutan pada orang lanjut usia, sementara kadar hemoglobin dan asam urat menunjukkan kemampuan prediksi yang terbatas.

Kata kunci: Antropometri, Asam Urat, Hemoglobin, Kesehatan Metabolik, Lemak Subkutan

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1. INTRODUCTION

Subcutaneous fat deposition is a key factor influencing overall health, playing a significant role in metabolic regulation, energy balance, and the risk of chronic diseases such as obesity and cardiovascular conditions. Understanding and accurately predicting subcutaneous fat accumulation is critical for early intervention and effective management of these health risks. To achieve this, simple and accessible predictive tools, such as anthropometric measurements and laboratory variables, play an essential role. (Chandrasekaran & Weiskirchen, 2024; Després, 2012)

Anthropometric measurements, including body weight, body height, body mass index, total trunk muscle, total leg muscle, total arm muscle, and waist circumference, are widely used indicators that reflect body composition and fat distribution. These measurements are non-invasive, cost-effective, and provide direct insights into regional fat and muscle patterns, which are essential for evaluating health risks (Kwon et al., 2017; Wajchenberg, 2000). In parallel, simple laboratory variables such as hemoglobin and uric acid levels offer additional information about physiological and metabolic states that may influence fat deposition. (Blüher, 2020; Chandrasekaran & Weiskirchen, 2024) Despite the availability of these parameters, their combined predictive capability for subcutaneous fat deposition remains inadequately studied (Kwon et al., 2017; Yu, 2024). This study aims to investigate the correlation between hemoglobin levels, uric acid, and anthropometric parameters as predictors of subcutaneous fat deposition in elderly individuals.

2. METHODS

This study employs a cross-sectional design conducted at St. Asisi Church, involving 32 elderly groups. The research focuses on variables such as hemoglobin levels, uric acid, muscle composition, basic anthropometry, and subcutaneous fat deposition. Anthropometric measurements are carried out using the Body Composition Monitor (OMRON HBF-375), elastic tape, and digital height meter (GEA Medical HT721). Hemoglobin and uric acid levels are analyzed with the Fora 6 Plus device. Participants in this study are individuals aged 60 and above. Exclusion criteria include those who are uncooperative, unwilling to undergo examinations, or have incomplete data. The study procedure begins with participants completing a questionnaire, followed by anthropometric assessments. Statistical analysis is performed using the Spearman correlation test, with subcutaneous fat deposition as the reference standard. This study has undergone ethical review by Tarumanagara University.

3. RESULT AND DISCUSSION

The study included a total of 32 participants, all of whom were women (100%). The characteristics of the study respondents are presented in Table 1.

Table 1. Respondents Characteristics

Parameter	Results
Gender (%):	
• Woman	32(100)
• Man	0 (0)
Age, years	73 (55 – 87)
Body Weight, kg	55,18 (26,6 – 84,6)
Body Height, cm	151,25 (144 – 161)
Upper Arm Circumference, cm	27,5 (17 – 38)
Abdominal Circumference, cm	90 (73 – 119)
Calf Circumference, cm	33,5 (11,8 – 48)
Uric Acid, mg/dL	5,3 (3,4 – 8,8)
Hemoglobin, mg/dL	11,35 (4,4 – 13,9)
Total Skeletal Muscle, %	21,4 (14,9 – 26)
Trunk Skeletal Muscle, %	15,05 (12,4 – 20,6)
Upper Extremity Skeletal Muscle, %	22,75 (15,7 – 32,6)
Lower Extremity Skeletal Muscle, %	34,4 (30,3 – 38,3)
Total Subcutaneous Fat, %	31,15 (14,4 – 42,1)
Trunk Subcutaneous Fat, %	28,1 (11,2 – 37,7)
Arm Subcutaneous Fat, %	48,45 (29 – 56,7)
Leg Subcutaneous Fat, %	40,15 (20,2 – 53,4)

The table 2 shows the correlation analysis results between various parameters and subcutaneous fat distribution (total, trunk, arm, and leg) in a sample of 32 individuals. Body weight and upper arm circumference exhibit strong positive correlations ($r > 0.9$, $p < 0.001$) with total, trunk, arm, and leg subcutaneous fat. Abdominal and calf circumferences also show significant positive correlations across all fat regions ($p < 0.001$). In contrast, skeletal muscle percentage (total, trunk, and upper extremity) has strong negative correlations with all subcutaneous fat measures (r ranging from -0.493 to -0.978, $p < 0.001$). Other variables, like age, height, and hemoglobin levels, show weaker or non-significant correlations, with some exceptions, such as uric acid moderately correlating with trunk and leg subcutaneous fat.

Table 2. Correlation of Hemoglibin, Uric Acid and Anthropometric to Subcutaneous Fat Deposition

Parameter (N=32)	Total Subcutaneous Fat, %		Trunk Subcutaneous Fat, %		Arm Subcutaneous Fat, %		Leg Subcutaneous Fat, %	
	r	***p***	**r**	***p***	**r**	***p***	**r**	***p***
Age, years	-0,293	0,103	-0,269	0,137	-0,239	0,189	-0,324	0,070
Body Weight, kg	0,915	<0,001	0,874	<0,001	0,762	<0,001	0,884	<0,001
Body Height, cm	-0,085	0,646	-0,129	0,482	-0,186	0,308	-0,075	0,684
Upper Arm Circumference, cm	0,927	<0,001	0,900	<0,001	0,800	<0,001	0,894	<0,001
Abdominal Circumference, cm	0,845	<0,001	0,824	<0,001	0,751	<0,001	0,821	<0,001
Calf Circumference, cm	0,663	<0,001	0,618	<0,001	0,536	0,002	0,653	<0,001
Uric Acid, mg/dL	0,486	0,005	0,462	0,008	0,369	0,038	0,445	0,011
Hemoglobin, mg/dL	0,039	0,833	0,071	0,699	0,108	0,555	0,058	0,753
Total Skeletal Muscle, %	-0,493	0,004	-0,579	<0,001	-0,670	<0,001	-0,535	<0,001
Trunk Skeletal Muscle, %	-0,827	<0,001	-0,885	<0,001	-0,936	<0,001	-0,851	<0,001
Upper Extremity Skeletal Muscle, %	-0,976	<0,001	-0,993	<0,001	-0,971	<0,001	-0,978	<0,001
Lower Extremity Skeletal Muscle, %	0,095	0,606	-0,007	0,970	-0,211	0,246	0,010	0,959

*Analysis using Spearman Correlation

**r: r-correlation; *p*: *p*-value (5%)

Waist circumference is commonly used to assess central obesity, but its positive association with subcutaneous fat. It primarily correlates with visceral fat, which accumulates around internal organs rather than beneath the skin. Visceral fat differs from subcutaneous fat in its metabolic activity and stronger connection to health risks. It is metabolically more active, releasing inflammatory cytokines and free fatty acids that can contribute to insulin resistance, elevated blood pressure, and an increased risk of metabolic disorders such as type 2 diabetes and cardiovascular disease. (Indraswari et al., 2021; Ross et al., 2020)

While waist circumference reflects visceral fat more strongly, it can also give some indication of subcutaneous fat, especially in individuals with more abdominal fat. However, waist circumference alone is not an accurate measure of subcutaneous fat, as it does not differentiate between the two types of fat. In individuals with a leaner build or more evenly distributed subcutaneous fat, waist circumference may not offer an accurate assessment. (Nauli & Matin, 2019; Sanches et al., 2008)

The association between height and trunk subcutaneous fat highlights height as a possible protective factor against central fat deposition, likely due to differences in body proportions and metabolic efficiency. This more balanced fat distribution results in less fat buildup in the central area. (Wajchenberg, 2000) This could also be due to body proportions, as taller people often have longer limbs and torsos, which facilitates a more efficient allocation of fat and muscle.(Kahn et al., 2014) In this case, the processes that regulate fat storage may be better spread across the body, reducing excess fat in the trunk. Taller individuals may also experience greater metabolic efficiency, which further prevents the accumulation of central fat. This suggests that height, through body proportions and metabolic factors, could naturally protect against trunk fat storage. (Wajchenberg, 2000)

The connection between height and reduced central fat may also involve hormonal and genetic factors that influence how fat is distributed. Taller individuals often have a higher lean body mass, especially in muscle, which can improve insulin sensitivity and fat metabolism. (Kahn et al., 2014) These factors, along with height-related body proportions, help achieve a more even fat distribution and lower the risk of central obesity, which is linked to various metabolic and cardiovascular conditions. (Wajchenberg, 2000) This relationship between the BMI to trunk subcutaneous fat is likely reflects the influence of muscle mass or lean body composition in individuals with higher BMI, which can counterbalance fat accumulation.(Kahn et al., 2014) This underscores the complexity of BMI as a measure, demonstrating that it does not always directly equate to excess fat storage, especially in specific body regions like the trunk. (Wajchenberg, 2000)

Individuals with higher BMI due to increased muscle mass often show a negative correlation with trunk subcutaneous fat, reflecting the balancing role of lean tissue in fat accumulation. Muscle actively boosts the basal metabolic rate (BMR), helping regulate energy balance and reducing fat storage, particularly in the trunk. (Gilsanz et al., 2009) Additionally, individuals with greater lean body mass often maintain better metabolic health, with enhanced insulin sensitivity that mitigates central fat deposition. (Kahn et al., 2014) This correlation underscores the importance of incorporating additional measures alongside BMI to assess body fat and its distribution accurately. (Wajchenberg, 2000) Methods like dual-energy X-ray absorptiometry (DEXA) or bioelectrical impedance analysis (BIA) effectively differentiate between lean and fat mass, offering a clearer picture of body composition. (Pereira et al., 2015) These findings reveal that BMI reflects more than just fat mass, especially in individuals with higher muscle development or other weight-contributing components. (Kahn et al., 2014)

Fat distribution variability among individuals further complicates BMI interpretation.(Kahn et al., 2014) Subcutaneous fat, stored beneath the skin, and visceral fat, surrounding internal organs, differ in their metabolic and health effects. (Gilsanz et al., 2009)

A higher BMI may indicate increased visceral fat rather than subcutaneous fat in some individuals, explaining the negative association between BMI and trunk subcutaneous fat in specific cases. (Pereira et al., 2015)

Muscle mass in the arms and legs and trunk subcutaneous fat emphasizes the protective role of muscle against central fat accumulation. (Ferreira et al., 2004) Higher muscle mass increases basal metabolic rates and enhances insulin sensitivity, which can reduce fat deposition in the trunk. (Contreiro et al., 2020) With more muscle, the body responds better to insulin, helping to prevent fat accumulation in the trunk area. (Kahn et al., 2014) Muscles can store and use glucose more effectively, reducing the likelihood of fat being deposited in the central region. (Contreiro et al., 2020) Additionally, greater muscle mass helps shift the balance between fat and lean tissue, leading to more even fat distribution.(Ferreira et al., 2004) This prevents fat from accumulating in the trunk, reducing the risks of metabolic disorders, insulin resistance, and cardiovascular diseases associated with central obesity. (Wajchenberg, 2000)

Hemoglobin, a protein responsible for oxygen delivery to tissues and the removal of carbon dioxide, plays a central role in cellular respiration and energy production. Elevated hemoglobin levels may enhance oxygen availability, potentially influencing metabolic activity in ways that promote fat storage in the trunk region.(Kuroiwa et al., 2019; Sucharita et al., 2019) This relationship may also reflect an adaptive response to increased energy demands or underlying metabolic conditions that affect fat distribution. For instance, higher hemoglobin levels could indicate heightened metabolic processes, which may inadvertently contribute to localized fat deposition.(Tapio et al., 2021) Additionally, systemic factors like inflammation or oxidative stress, often associated with elevated hemoglobin levels, could play a role. (T. Wang et al., 2023)

Chronic low-grade inflammation linked to increased red blood cell production might disrupt normal fat metabolism, favoring fat accumulation in central areas. (Tapio et al., 2021; T. Wang et al., 2023) Despite these observations, the exact mechanisms driving the association remain unclear. The interplay between hemoglobin and fat storage likely involves multiple factors beyond oxygen transport, including hormonal, inflammatory, and metabolic pathways. (Kuroiwa et al., 2019; Sucharita et al., 2019) Future studies should explore whether hemoglobin actively contributes to trunk fat deposition or serves as a biomarker for other underlying processes. Clarifying this link could offer valuable insights into the metabolic regulation of fat distribution and its implications for health. (Tapio et al., 2021; T. Wang et al., 2023)

Serum uric acid (SUA) levels have been strongly associated with increased visceral fat and the components of metabolic syndrome. (Li et al., 2023) Previous studies have demonstrated a positive correlation between SUA and visceral fat area, linking higher uric acid levels to central fat accumulation. (Ran et al., 2021) However, the inverse association with trunk subcutaneous fat observed in this study indicates that uric acid may influence fat distribution differently, favoring visceral over subcutaneous fat deposition. (H. P. Wang et al., 2023)

This inverse relationship could stem from metabolic processes driven by elevated uric acid that preferentially promote visceral fat accumulation. (Li et al., 2023) Visceral fat, located around internal organs, is metabolically active and associated with insulin resistance and inflammation. (Ran et al., 2021) In contrast, subcutaneous fat, stored beneath the skin, is less metabolically detrimental. The findings suggest that uric acid may modulate pathways that increase visceral adiposity while limiting subcutaneous fat storage. (Li et al., 2023)

Genetic and hormonal factors may further mediate this relationship, contributing to variations in fat distribution and uric acid metabolism across individuals. (Ran et al., 2021) For instance, studies in populations with metabolic-associated fatty liver disease (MAFLD) have shown that higher SUA levels are linked to increased abdominal fat and insulin resistance. (H. P. Wang et al., 2023) These observations highlight the importance of individual variability in understanding the complex role of uric acid in fat storage dynamics. (Li et al., 2023)

The negative correlation between height and arm fat indicates that taller individuals tend to store less fat in their arms, likely due to their larger body surface area and higher metabolic activity. According to the energy expenditure theory, taller individuals generally have elevated basal metabolic rates, which promote greater overall energy utilization and reduce localized fat storage in the arms. (Rask-Andersen et al., 2019) The inverse link between BMI and arm fat reflects a shift in fat storage to other areas, such as the abdomen or thighs, in individuals with higher body mass. This pattern aligns with the regional fat storage theory, which suggests that hormonal and metabolic factors influence where fat is deposited. Central fat storage, driven by insulin resistance and elevated cortisol levels, often takes priority over peripheral fat storage in those with higher adiposity. (Ceccarelli et al., 2020; J. Wang et al., 2022)

The positive association between upper body muscle mass and arm fat reveals a systemic interaction between muscle and fat within the same region. (Landers et al., 2001) According to the metabolic coupling theory, an increase in muscle mass signals the body to store more fat in nearby areas, such as the arms, to provide additional energy reserves needed for muscle function. This suggests that muscle growth in a specific area may lead to greater fat accumulation in the same region to meet the energy demands of the muscle. (Ran et al., 2021)

Conversely, the competitive allocation theory highlights that muscle and fat compete for resources in the body.(Ran et al., 2021) As muscle mass increases in the arms, fewer resources are available for fat storage in the same area, resulting in less fat in regions with more muscle development.(Ferreira et al., 2004) This theory is supported by the negative relationship between arm muscle mass and arm fat, where greater muscle mass correlates with reduced fat storage in the arms. (Li et al., 2023)

The positive link between leg muscle mass and arm fat highlights the systemic influence of muscle tissue on fat storage. Greater leg muscle mass may reflect an overall increase in energy storage, including fat in the arms, to support metabolic demands. (Rask-Andersen et al., 2019) Similarly, the significant positive association between hemoglobin levels and arm fat points to the role of hemoglobin in oxygen delivery. Higher hemoglobin levels enhance oxidative capacity, enabling a balance between energy storage and usage, which supports fat deposition in the arms. (Kuroiwa et al., 2019; Tapio et al., 2021)

The analysis highlights several important relationships that help explain subcutaneous fat The analysis reveals critical insights into the factors influencing subcutaneous fat distribution in the legs. The negative association between height and leg fat can be explained by differences in body proportions and metabolic efficiency. Taller individuals often possess greater lean mass and longer limbs, which promote higher energy expenditure and fat oxidation, reducing fat accumulation in the legs. This observation aligns with the energy balance theory, which posits that individuals with elevated metabolic rates are less likely to store fat in specific regions due to increased caloric demands. (Bender et al., 2020; Shirley et al., 2022)

The inverse relationship between BMI and leg fat reflects a pattern where individuals with higher BMI store fat preferentially in other areas, such as the abdomen. This supports the regional fat distribution theory, which suggests that hormonal factors like cortisol and insulin resistance drive central fat deposition in individuals with greater overall adiposity. This pattern aligns with the concept of metabolic prioritization, where fat is stored in regions that play a more active role in energy regulation and hormonal signaling. (Alser et al., 2024)

The positive link between upper body muscle mass and leg fat highlights systemic interactions between muscle and fat. According to the metabolic coupling theory, muscle and fat tissues across the body work together to balance energy storage and utilization. Increased upper body muscle mass may signal a need for greater energy reserves, resulting in higher fat storage in the legs. On the other hand, the negative association between arm muscle mass and leg fat aligns with the competitive resource allocation theory, which suggests that muscle growth in one area may reduce the resources available for fat storage in other regions. (Blüher & Laufs, 2019; Lassek & Gaulin, 2006)

The positive correlation between leg muscle mass and leg fat further supports the concept of localized energy demands. Muscles in the legs require substantial energy for movement and weight support, leading to localized fat deposition as a convenient energy source. This aligns with the functional adaptation theory, which posits that fat is stored near regions with high energy needs to optimize function and endurance. Additionally, the role of hemoglobin in influencing leg fat can be attributed to its critical function in oxygen delivery. Hemoglobin enhances the oxidative capacity of leg muscles, helping to balance fat storage and usage effectively. (Blüher & Laufs, 2019)

4. CONCLUSION

This study highlights the significant correlations between hemoglobin levels, uric acid, and anthropometric parameters in predicting subcutaneous fat deposition among elderly individuals. Findings indicate that body weight, upper arm circumference, abdominal circumference, and calf circumference are strong positive predictors of subcutaneous fat, while skeletal muscle percentage has an inverse relationship with fat accumulation. Notably, hemoglobin levels and uric acids showed a weaker correlation with fat deposition, suggesting a more complex interplay between oxygen transport and metabolic activity.

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