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Association Of Anthropometric Measurement, Uric Acid, Vitamin D, Albumin, And Diabetes Mellitus With Frailty In The Elderly: A Study At Bina Bhakti Elderly Home

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Abstract. *Frailty is a common syndrome in older adults, marked by declining physiological reserves and increased vulnerability to adverse health outcomes. It impacts quality of life and links to higher morbidity, mortality, and healthcare needs. Identifying frailty markers early helps prevent or delay its onset. In Indonesia, frailty affects 10–20% of the elderly, with higher rates in rural areas and those over 75, driven by poor nutrition, chronic diseases, and limited healthcare access. This study explores these factors and their relationship with frailty in elderly residents of Bina Bhakti Elderly Home. This cross-sectional study analyzed anthropometric measurement, uric acid, vitamin D, albumin, and diabetes mellitus with frailty in 42 elderly residents, excluding those with cognitive impairments, acute illnesses, or psychiatric disorders. The analysis identified fasting blood glucose, HbA1c, and albumin as significant predictors of frailty, highlighting the importance of glucose regulation and nutritional status in frailty risk among the studied population. Fasting blood glucose, HbA1c, and albumin emerged as key predictors of frailty, highlighting the roles of glycemic control and nutritional health in reducing frailty risk. Lower fasting blood glucose and higher albumin levels were protective, while higher HbA1c increased vulnerability. Targeted interventions in these areas may effectively mitigate frailty risk.*

Keywords: *Albumin, Anthropometry, Diabetes mellitus, Frailty, Uric acid*

Abstrak. Frailty (kerentaan) merupakan sindrom yang umum terjadi pada lansia, ditandai oleh penurunan cadangan fisiologis dan meningkatnya kerentanan terhadap berbagai masalah kesehatan. Kondisi ini berdampak pada penurunan kualitas hidup serta berkaitan dengan peningkatan angka morbiditas, mortalitas, dan kebutuhan layanan kesehatan. Identifikasi penanda frailty sejak dini penting untuk mencegah atau menunda timbulnya kondisi ini. Di Indonesia, frailty memengaruhi sekitar 10–20% populasi lansia, dengan prevalensi lebih tinggi di daerah pedesaan dan pada individu usia di atas 75 tahun, yang dipengaruhi oleh faktor seperti malnutrisi, penyakit kronis, dan keterbatasan akses layanan kesehatan. Penelitian ini bertujuan untuk mengeksplorasi faktor-faktor tersebut dan hubungannya dengan frailty pada penghuni lanjut usia di Panti Werdha Bina Bhakti. Penelitian ini menggunakan desain potong lintang (cross-sectional) yang menganalisis hubungan antara pengukuran antropometri, kadar asam urat, vitamin D, albumin, dan diabetes melitus dengan kejadian frailty pada 42 penghuni lanjut usia. Responden dengan gangguan kognitif, penyakit akut, atau gangguan kejiwaan dikeluarkan dari penelitian. Analisis menunjukkan bahwa kadar glukosa darah puasa, HbA1c, dan albumin merupakan prediktor signifikan dari kejadian frailty. Temuan ini menyoroti pentingnya regulasi glukosa darah dan status nutrisi dalam risiko frailty pada populasi yang diteliti. Glukosa darah puasa, HbA1c, dan albumin muncul sebagai prediktor utama frailty, yang menunjukkan peran penting kontrol glikemik dan kesehatan nutrisi dalam menurunkan risiko frailty. Kadar glukosa darah puasa yang lebih rendah dan kadar albumin yang lebih tinggi bersifat protektif, sedangkan kadar HbA1c yang tinggi meningkatkan kerentanan. Intervensi yang ditargetkan pada aspek-aspek ini berpotensi efektif dalam mengurangi risiko frailty.

Kata kunci: Albumin, Antropometri, Asam urat, Diabetes melitus, Frailty

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1. INTRODUCTION

Frailty is a common syndrome in older adults, characterized by a decline in physiological reserves and an increased vulnerability to adverse health outcomes. It significantly impacts the quality of life and is associated with higher morbidity, mortality, and healthcare utilization. Identifying early markers of frailty can help in preventing or delaying its onset, ultimately improving elderly care and outcomes. (Chen et al., 2014; Xue, 2011)

The prevalence of frailty among older populations is a growing concern worldwide, and Indonesia is no exception. According to recent studies, the prevalence of frailty in the elderly population in Indonesia ranges between 10% and 20%, with higher rates observed in rural areas and in individuals aged 75 years and older. Factors contributing to the high prevalence of frailty in Indonesia include poor nutrition, chronic diseases, limited physical activity, and inadequate access to healthcare services. The country's rapidly aging population, with an increasing proportion of individuals over the age of 60, further underscores the need to address frailty as a public health priority. (Pradana et al., 2023)

Various factors are believed to contribute to the development of frailty, including anthropometric measurements, serum markers, and chronic conditions like diabetes mellitus. Anthropometric indicators such as body mass index (BMI), waist-to-hip ratio, and muscle mass are key measures of nutritional status and physical function, all of which are closely linked to frailty. Frail individuals often exhibit low muscle mass, poor nutritional status, and diminished functional capacity, leading to weakness and increased vulnerability to health complications. (Wang et al., 2022)

Uric acid, a byproduct of purine metabolism, has been shown to have both protective and harmful effects in older adults. While it serves as an antioxidant, excessive uric acid levels have been associated with inflammatory processes and conditions like gout, which can exacerbate frailty. Additionally, Vitamin D deficiency is increasingly recognized as a risk factor for frailty, with low levels contributing to muscle weakness, osteoporosis, and impaired mobility, all of which are hallmarks of frailty. (Kang et al., 2024)

Albumin, a protein that reflects nutritional status and liver function, has been shown to correlate with frailty, with lower albumin levels often indicating malnutrition, chronic disease, and increased frailty risk. Moreover, Diabetes Mellitus, a common chronic condition in the elderly, is frequently associated with frailty due to its effects on metabolic and inflammatory pathways, which can accelerate the aging process and increase the risk of functional decline. (Riviati et al., 2024; Yamamoto et al., 2021)

This study aims to explore the relationship between anthropometric measures, uric acid, Vitamin D, albumin, and Diabetes Mellitus with frailty among elderly residents at Bina Bhakti Elderly Home.

2. METHODS

This cross-sectional study aimed to explore the relationship between anthropometric measures, uric acid, Vitamin D, albumin, and Diabetes Mellitus with frailty in elderly residents at Panti Werdha Yayasan Bina Bhakti. A total of 42 elderly participants, aged 60 years or older, were selected based on inclusion criteria: providing informed consent, and having no severe cognitive impairments or acute illnesses that could interfere with participation. Individuals with significant psychiatric disorders, recent hospitalizations, or acute infections were excluded from the study.

This study evaluated various anthropometric parameters to assess body composition and nutritional status. Measurements included calf circumference, mid upper arm circumference, and waist circumference, all taken using a flexible tape measure for accuracy. Waist circumference, specifically, was measured at the midpoint between the lower rib and iliac crest to assess abdominal fat distribution. Participants' weight was recorded using a standard scale, while height was measured with a stadiometer (microtoise) to ensure precision. Body Mass Index (BMI) was then calculated, and additional insights into body fat percentage and muscle mass were obtained using the Omron Body Composition Analyzer (HBF-375).

Biochemical markers were assessed through blood samples collected after an overnight fast. Uric acid levels were determined using enzymatic methods, while serum 25-hydroxyvitamin D (Vitamin D levels) was measured using enzyme-linked immunosorbent assay (ELISA). Albumin levels were assessed following routine laboratory protocols. For diabetes mellitus analysis, fasting insulin, fasting blood glucose, HOMA-IR (Homeostatic Model Assessment for Insulin Resistance), and HbA1c levels were measured in accordance with standardized laboratory procedures.

Frailty was evaluated using the Fried Frailty Criteria, encompassing five key components: unintentional weight loss (≥5% of body weight in the last six months), self-reported exhaustion (assessed via the CES-D scale), weak grip strength (measured with a handgrip dynamometer), slow walking speed (measured over a 4-meter distance), and low physical activity (evaluated using the Physical Activity Scale for the Elderly). Participants were categorized as frail if they met three or more criteria, pre-frail if they met two, and non-frail if they met one or none.

For statistical analysis, multiple linear regression was used to evaluate the relationships between frailty and the independent variables, including anthropometric measures, uric acid, Vitamin D, albumin, and panel diabetes mellitus. This method was employed to determine the predictive power of these variables on frailty scores while adjusting for potential confounding factors. The regression model allowed for an assessment of the relative contributions of the independent variables to frailty. Descriptive statistics, including mean, standard deviation, and percentage, were used to summarize participant characteristics. Statistical significance was set at $p < 0.05$, and all analyses were performed using SPSS version 25.

The study was approved by the Tarumanagara University Human Research Ethics Committee, under the Institute of Research and Community Engagement. Informed consent was obtained from all participants.

3. RESULT AND DISCUSSION

The study sample consisted primarily of older adults with a mean age of 73.12 years, and females made up 78.6% of the group. Participants generally had BMI values within the normal to overweight range (mean: 21.63 kg/m^2). Fasting blood glucose and HbA1c levels indicated impaired glucose regulation. Insulin levels and HOMA-IR values showed that 45.2% of participants had low insulin resistance, while 54.8% fell within the normal range, highlighting variability in insulin sensitivity. Participants exhibited waist circumferences and body weights typical of an older adult population, while vitamin D levels appeared relatively low, suggesting a potential risk of deficiency. (Table 1)

Tabel 1. Characteristics of Research Results

Parameter	N (%)	Mean (SD)	Med (Min - Max)
Gender			
• Female	33 (78.6)		
• Male	9 (21.4)		
Age		73.12 (1.07)	74.5 (61 – 88)
• 61 – 70 years	13 (31)		
• 71 – 80 years	24 (57.1)		
• 81 – 90 years	5 (11.9)		
Calf Circumference		29.38 (0.73)	31 (16 – 38)
Mid Upper Arm Circumference (MUAC)		23.48 (0.64)	7.75 (1 – 35)
Waist Circumference		83.69 (1.89)	84 (56 – 117)
Body Weight		48.94 (1.77)	48.15 (30 – 83)
Body Height		149.75 (1.41)	149.25 (134 – 171)

Body Mass Index (BMI)		21.63 (0.55)	21.76 (14.28 – 33.51)
Fasting Blood Glucose		88.57 (3.13)	86 (63 – 166)
HbA1c		7.67 (0.22)	7.6 (5.7 – 12)
Insulin		5.06 (0.26)	4.52 (2.56 – 8.80)
Albumin		3.85 (0.07)	3.9 (2.9 – 4.8)
Uric Acid		4.24 (0.17)	4.1 (2.7 – 7.4)
Vitamin D 25-OH		9.75 (0.76)	7.45 (5.7 – 25.6)
HOMA-IR		1.1 (0.07)	1.13 (0.53 – 2.58)
• Low	19 (45.2)		
• Normal	23 (54.8)		

The regression analysis revealed key predictors of frailty. In the simplified model, fasting blood glucose (B = -0.029; *p* = 0.009), HbA1c (B = 0.312; *p* = 0.043), and albumin (B = -0.770, *p* = 0.039) showed statistically significant associations with frailty. Higher HbA1c levels were positively associated with frailty, while lower fasting blood glucose and albumin levels were negatively associated with frailty. These findings highlight the role of glucose regulation and nutritional status in influencing frailty risk within the studied population. (Table 2)

Tabel 2. Regression Analysis of Factors Associated with Frailty

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.689	25.713		.493	.626
	Age	.021	.029	.130	.743	.464
	Calf Circumference	-.058	.072	-.240	-.804	.429
	Mid Upper Arm Circumference (MUAC)	.057	.097	.205	.590	.560
	Waist Circumference	.004	.029	.040	.132	.896
	Body Weight	.122	.247	1.220	.496	.624
	Body Height	-.079	.160	-.627	-.495	.625
	Body Mass Index (BMI)	-.283	.558	-.882	-.506	.617
	Fasting Blood Glucose	-.014	.031	-.239	-.442	.662
	HbA1c	.339	.204	.420	1.662	.108
	Insulin	.161	.519	.240	.311	.758
	Albumin	-.719	.442	-.297	-1.626	.116
	Uric Acid	.186	.214	.177	.870	.392
	Vitamin D 25-OH	.049	.039	.208	1.232	.228
	HOMA-IR	-1.359	2.389	-.505	-.569	.574
12	(Constant)	4.629	1.677		2.760	.009
	Fasting Blood Glucose	-.029	.011	-.517	-2.766	.009
	HbA1c	.312	.149	.387	2.090	.043
	Albumin	-.770	.360	-.318	-2.140	.039

- Dependent Variable: FRAIL

The regression results provide valuable insights into the factors influencing FRAIL, highlighting the interplay between metabolic, nutritional, and anthropometric variables. While the full model includes several predictors, most show limited statistical significance, suggesting that these factors may not independently contribute to variations in FRAIL. This lack of significance might result from multicollinearity, an inadequate sample size, or a weak theoretical relationship between some predictors and the dependent variable.

The relationship between Fasting Blood Glucose (FBG) and frailty is grounded in the understanding that chronic dysregulation of glucose metabolism can lead to various complications that contribute to physical decline. When glucose levels remain consistently high, they can damage blood vessels, impair endothelial function, and trigger inflammation. (Zaslavsky et al., 2016) These processes can increase the risk of cardiovascular disease, which is often associated with frailty, particularly in older adults. Additionally, high glucose levels may interfere with muscle function and regeneration by altering protein synthesis and increasing oxidative stress, both of which are critical to maintaining muscle mass and strength. This is particularly important because muscle mass and strength are core components of frailty, and loss of muscle can significantly contribute to the condition. (Abdelhafiz et al., 2016; Guevara et al., 2024)

On the other hand, HbA1c serves as a long-term marker of blood glucose control and reflects chronic hyperglycemia over a span of 2-3 months. Its positive association with frailty further supports the idea that sustained high blood glucose levels over time can increase the risk of frailty. Elevated HbA1c levels are often linked to insulin resistance and metabolic dysfunction, both of which can interfere with normal physiological processes. Insulin resistance, in particular, leads to an impaired ability to regulate blood glucose and store energy in muscle and fat tissues, leading to an imbalance that can accelerate muscle wasting and physical deterioration, hallmarks of frailty. (Aguayo et al., 2019)

Moreover, FBG and HbA1c correlate chronic metabolic stress play a critical role in the development of frailty. Conditions like insulin resistance and poor glycemic control are known to induce inflammatory pathways, which can contribute to muscle breakdown, cognitive decline, and overall diminished health. Inflammation can be chronic and low-grade, influencing muscle tissue and other organs in ways that accelerate aging. Furthermore, metabolic dysfunction may impair mitochondrial function, reduce energy production, and increase oxidative stress, all of which can directly impact physical function and contribute to the decline observed in frailty. (Sadiq Ahmed et al., 2021)

Albumin is a widely recognized biomarker of nutritional and health status, and its negative relationship with frailty underscores its central role in maintaining physical resilience. As a protein produced primarily by the liver, albumin serves several physiological functions, including maintaining oncotic pressure, transporting hormones and nutrients, and acting as an antioxidant. These functions are critical for sustaining overall health and physical functionality, especially in older adults, where frailty becomes more prevalent. (Erdoğan et al., 2024; Keller, 2019)

Low albumin levels often signal malnutrition, which is a significant risk factor for frailty. Protein-energy malnutrition, in particular, can lead to muscle wasting, reduced immune function, and diminished physical strength, all of which contribute to the development of frailty. (Yamamoto et al., 2021) Albumin is also a marker of systemic inflammation, as inflammatory conditions often suppress albumin production in the liver while increasing its catabolism. (Riviati et al., 2024) Chronic illnesses, such as liver disease, kidney dysfunction, or infections, can further deplete albumin levels, exacerbating the risk of frailty. (Kobayashi et al., 2023)

The association between albumin and frailty is also tied to the role of protein intake in maintaining muscle mass and function. Albumin levels are an indirect reflection of protein status in the body. (Liang et al., 2021) Insufficient dietary protein intake reduces the availability of amino acids necessary for muscle repair and synthesis. Over time, this deficiency contributes to sarcopenia (loss of muscle mass and strength), which is a key component of frailty. (Tomata et al., 2021) Conversely, adequate protein intake and nutritional interventions can help improve albumin levels and support muscle maintenance, reducing the likelihood of frailty. (Coelho-Junior et al., 2020)

Additionally, lower albumin levels correlate with poorer outcomes in various health conditions. In the context of frailty, low albumin levels may indicate underlying physiological stress, such as oxidative stress or metabolic dysfunction, which can impair recovery from illness or injury. Frail individuals with low albumin levels often face higher risks of hospitalization, longer recovery times, and worse overall health outcomes, highlighting the importance of addressing nutritional and health deficiencies early. (Bucci et al., 2024; Gounden et al., 2022)

Nutritional interventions play a critical role in mitigating frailty and improving albumin levels. High-quality protein sources, adequate caloric intake, and supplementation with specific nutrients, such as amino acids or vitamins, can positively impact albumin levels and overall health. (Liang et al., 2021) Strategies that combine nutritional support with resistance training or physical activity can further enhance physical resilience, muscle strength, and quality of life in frail or at-risk individuals. (Yamamoto et al., 2021)

4. CONCLUSION

The regression analysis highlights fasting blood glucose, HbA1c, and albumin levels as key predictors of frailty in the studied population. Lower fasting blood glucose levels associate with a reduced risk of frailty, emphasizing the protective role of maintaining healthy glucose regulation. Similarly, higher albumin levels negatively correlate with frailty, underscoring the importance of good nutritional status in promoting physical resilience and reducing frailty risk. In contrast, higher HbA1c levels show a positive relationship with frailty, suggesting that poor long-term glycemic control increases vulnerability to frailty. The analysis finds no strong associations for variables like age, body mass index (BMI), waist circumference, or insulin levels, indicating these factors have limited influence on frailty within this population. These findings emphasize the critical roles of glycemic control and nutritional health in predicting frailty, supporting the need for targeted interventions in these areas to effectively mitigate frailty risk.

REFERENCES

Abdelhafiz, A. H., Koay, L., & Sinclair, A. J. (2016). The effect of frailty should be considered in the management plan of older people with Type 2 diabetes. *Future Science OA*, *2*(1), 102. https://doi.org/10.4155/FSOA-2015-0016

Aguayo, G. A., Hulman, A., Vaillant, M. T., Donneau, A. F., Schritz, A., Stranges, S., Malisoux, L., Huiart, L., Guillaume, M., Sabia, S., & Witte, D. R. (2019). Prospective Association Among Diabetes Diagnosis, HbA1c, Glycemia, and Frailty Trajectories in an Elderly Population. *Diabetes Care*, *42*(10), 1903–1911. https://doi.org/10.2337/DC19-0497

Bucci, T., Pastori, D., Pignatelli, P., Ntaios, G., Abdul-Rahim, A. H., Violi, F., & Lip, G. Y. H. (2024). Albumin Levels and Risk of Early Cardiovascular Complications after

Ischemic Stroke: A Propensity-Matched Analysis of a Global Federated Health Network. *Stroke*, *55*(3), 604–612. https://doi.org/10.1161/STROKEAHA.123.044248/SUPPL_FILE/STR_STROKE-2023-044248_SUPP2.PDF

Chen, X., Mao, G., & Leng, S. X. (2014). Frailty syndrome: an overview. *Clinical Interventions in Aging*, *9*, 433. https://doi.org/10.2147/CIA.S45300

Coelho-Junior, H. J., Marzetti, E., Picca, A., Cesari, M., Uchida, M. C., & Calvani, R. (2020). Protein Intake and Frailty: A Matter of Quantity, Quality, and Timing. *Nutrients 2020, Vol. 12, Page 2915*, *12*(10), 2915. https://doi.org/10.3390/NU12102915

Erdoğan, K., Kara, M., Şener, F. E., Durmuş, M. E., Durmuşoğlu, B. N. Ç., Abdulsalam, A. J., Sezer, S., Kara, Ö., Kaymak, B., & Özçakar, L. (2024). Serum albumin as a biomarker of (nutritional status in) sarcopenia. *Journal of Bone and Mineral Metabolism*. https://doi.org/10.1007/S00774-024-01557-9

Gounden, V., Vashisht, R., & Jialal, I. (2022). Hypoalbuminemia. *StatPearls*, 5–9.

Guevara, E., Simó-Servat, A., Perea, V., Quirós, C., Puig-Jové, C., Formiga, F., & Barahona, M. J. (2024). Frailty Detection in Older Adults with Diabetes: A Scoping Review of Assessment Tools and Their Link to Key Clinical Outcomes. *Journal of Clinical Medicine 2024, Vol. 13, Page 5325*, *13*(17), 5325. https://doi.org/10.3390/JCM13175325

Kang, M. gu, Baek, J. Y., Jo, Y., Ryu, D., Jang, I. Y., Jung, H. W., & Kim, B. J. (2024). Higher serum uric acid as a risk factor for frailty in older adults: A nationwide population-based study. *Journal of Cachexia, Sarcopenia and Muscle*, *15*(5), 2134. https://doi.org/10.1002/JCSM.13561

Keller, U. (2019). Nutritional Laboratory Markers in Malnutrition. *Journal of Clinical Medicine*, *8*(6), 775. https://doi.org/10.3390/JCM8060775

Kobayashi, K., Nishida, T., & Sakakibara, H. (2023). Factors Associated with Low Albumin in Community-Dwelling Older Adults Aged 75 Years and Above. *International Journal of Environmental Research and Public Health 2023, Vol. 20, Page 6994*, *20*(21), 6994. https://doi.org/10.3390/IJERPH20216994

Liang, H., Li, X., Lin, X., Ju, Y., & Leng, J. (2021). The correlation between nutrition and frailty and the receiver operating characteristic curve of different nutritional indexes for frailty. *BMC Geriatrics*, *21*(1), 619. https://doi.org/10.1186/S12877-021-02580-5

Pradana, A. A., Chiu, H. L., Lin, C. J., & Lee, S. C. (2023). Prevalence of frailty in Indonesia: a systematic review and meta-analysis. *BMC Geriatrics*, *23*(1). https://doi.org/10.1186/S12877-023-04468-Y

Riviati, N., Legiran, Indrajaya, T., Saleh, I., Ali, Z., Irfannuddin, Probosuseno, & Indra, B. (2024). Serum Albumin as Prognostic Marker for Older Adults in Hospital and Community Settings. *Gerontology & Geriatric Medicine*, *10*, 23337214241249910. https://doi.org/10.1177/23337214241249914

Sadiq Ahmed, A.-A., Qasem Mohammed, A., Zainab Tariq, A., Zainab, A., Alhawraa Jassim

Ahmad, A., Aroob Nassir, A., & Hassan Ali, A. (2021). Screening of Diabetic Patients for Frailty with the Frail Scale: A Comparison with the Fried's Phenotype Criteria in Saudi Arabia. *International Journal of Diabetes and Clinical Research*, *8*(4), 150. https://doi.org/10.23937/2377-3634/1410150

Tomata, Y., Wang, Y., Hägg, S., & Jylhävä, J. (2021). Protein Nutritional Status and Frailty: A Mendelian Randomization Study. *The Journal of Nutrition*, *152*(1), 269. https://doi.org/10.1093/JN/NXAB348

Wang, X., Hu, J., & Wu, D. (2022). Risk factors for frailty in older adults. *Medicine*, *101*(34), e30169. https://doi.org/10.1097/MD.0000000000030169

Xue, Q. L. (2011). The Frailty Syndrome: Definition and Natural History. *Clinics in Geriatric Medicine*, *27*(1), 1. https://doi.org/10.1016/J.CGER.2010.08.009

Yamamoto, M., Adachi, H., Enomoto, M., Fukami, A., Nakamura, S., Nohara, Y., Sakaue, A., Morikawa, N., Hamamura, H., Toyomasu, K., & Fukumoto, Y. (2021). Lower albumin levels are associated with frailty measures, trace elements, and an inflammation marker in a cross-sectional study in Tanushimaru. *Environmental Health and Preventive Medicine*, *26*(1), 25. https://doi.org/10.1186/S12199-021-00946-0

Zaslavsky, O., Walker, R. L., Crane, P. K., Gray, S. L., & Larson, E. B. (2016). Glucose Levels and Risk of Frailty. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *71*(9), 1223. https://doi.org/10.1093/GERONA/GLW024