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The Correlation Between Body Composition and Mini Nutritional Assessment in The Elderly: A Cross-Sectional Study

Frisca Frisca[1*], Alexander Halim Santoso[2], Fiona Valencia Setiawan[3], Naufal Rayhan[4], Louise Audrey Sukianto[5]
[1-2] Department of Nutrition, Faculty of Medicine, Tarumanagara University
[3] Medical Profession Program, Faculty of Medicine, Tarumanagara University
[4-5] Undergraduate Medical Program, Faculty of Medicine, Tarumanagara University

Address: Letjen S. Parman Street No. 1, Tomang, Grogol Petamburan, RT.6/RW.16, Tomang, Grogol Petamburan, West Jakarta City, Special Capital Region of Jakarta 11440, Indonesia
**Corresponding Author: frisca@fk.untar.ac.id*

Abstract*. Aging leads to changes in body composition influenced by physical, psychological, and social factors. Understanding the relationship between fat distribution and nutritional status, particularly in older adults, is crucial for targeted interventions. This study examines the impact of body fat composition on nutritional assessment, particularly its influence on MNA scores in older adults. It aims to provide insights into how fat distribution and related metabolic changes affect nutritional status and inform targeted interventions for aging populations. The sample consisted of 31 elderly woman subjects selected through purposive sampling in a cross-sectional design from St. Francis of Assisi Catholic Church. Their nutritional status was determined using the MNA score, and the body composition measures were total body fat and skeletal muscle measured by the Omron Karada Scan HBF 375. SPSS analyzed statistical differences between body composition and MNA scores. This study found significant correlations between the Mini Nutritional Assessment scores and body composition parameters, including BMI (r = 0.473, p = 0.007), total subcutaneous fat (r = 0.468, p = 0.008), and visceral fat (r = 0.457, p = 0.010). Arm skeletal muscle showed a negative correlation (r = -0.486, p = 0.006). These results emphasize that fat composition is a critical determinant of nutritional status in the elderly. The study found a significant correlation between fat composition as a key determinant of nutritional status in the elderly, with significant correlations observed between MNA scores and various body fat parameters.*

Keywords*: Body Composition, Elderly, Mini Nutritional Assessment*

Abstrak. Penuaan menyebabkan perubahan komposisi tubuh yang dipengaruhi oleh faktor fisik, psikologis, dan sosial. Memahami hubungan antara distribusi lemak dan status gizi, terutama pada lansia, sangat penting untuk intervensi yang tepat sasaran. Penelitian ini mengkaji pengaruh komposisi lemak tubuh terhadap penilaian gizi, khususnya pengaruhnya terhadap skor MNA pada lansia. Penelitian ini bertujuan memberikan wawasan tentang bagaimana distribusi lemak dan perubahan metabolik terkait memengaruhi status gizi dan membantu merancang intervensi untuk populasi lansia. Sampel terdiri dari 31 wanita lanjut usia yang dipilih melalui purposive sampling dengan desain cross-sectional dari Gereja Katolik Santo Fransiskus dari Assisi. Status gizi mereka dinilai menggunakan skor MNA, sedangkan pengukuran komposisi tubuh, termasuk total lemak tubuh dan otot rangka, diukur menggunakan Omron Karada Scan HBF 375. Analisis statistik dilakukan menggunakan SPSS. Studi ini menemukan korelasi signifikan antara skor Mini Nutritional Assessment dan parameter komposisi tubuh, termasuk BMI (r = 0,473, p = 0,007), lemak subkutan total (r = 0,468, p = 0,008), dan lemak viseral (r = 0,457, p = 0,010). Otot rangka lengan menunjukkan korelasi negatif (r = -0,486, p = 0,006). Hasil ini menekankan bahwa komposisi lemak merupakan faktor penentu penting dalam status gizi lansia. Studi ini menemukan korelasi signifikan antara komposisi lemak sebagai faktor penentu utama status gizi pada lansia, dengan korelasi signifikan antara skor MNA dan berbagai parameter lemak tubuh.

Kata kunci: : Komposisi Tubuh, Lansia, Mini Nutritional Assessment.

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1. INTRODUCTION

Aging is a complex process and involves physical, psychological, and social changes in humans. The boundary of old age cannot be defined as the meaning differs in different societies.(Amarya et al., 2015) Aging is responsible for changes in body composition influenced by many factors. Muscle mass peaks in the fourth decade after which it is lost with aging, while fat and water content tends to increase more than lean mass until the middle or later years resulting in weight gain.(Batsis & Villareal, 2018; Sayer et al., 2008) The decline in muscle mass and strength nearly always occurs along with changes in body fat distribution in older adults and may cause several health complications.(Alley et al., 2008; Al-Sofiani et al., 2019; Santanasto et al., 2016) Body composition is mainly used to refer to fat distribution, one of the essential determinants of nutritional status.(Al-Sofiani et al., 2019; Ponti et al., 2020; Santoso et al., 2024) It can represent nutritional status using the mini nutritional assessment. (Palmer & Jensen, 2022)

MNA represents one of the generally accepted tools used to identify malnutrition risks among elderly persons based on anthropometric dietary and health-related parameters.(Al-Sofiani et al., 2019; Santanasto et al., 2016; Sowers et al., 2007) However, fat composition, though probably a determinant of nutritional status, has not received much attention in its contribution to the results of MNA.(Al-Sofiani et al., 2019; Ponti et al., 2020; Santanasto et al., 2016) These pathological changes in fat biology further enhance the inflammatory and metabolic dysregulation in older adults.(Al-Sofiani et al., 2019; Santanasto et al., 2016; Sowers et al., 2007) As a result, it does not merely affect energy balance but undercuts the effectiveness of the musculoskeletal system furthering limitations of physical activity along with dietary intake. (Wilson & Morley, 2003) The muscle becomes less responsive to growth stimuli with aging due to anabolic resistance, whereas fat tissue, in contrast, remains highly dynamic and of utmost importance in health (Endo et al., 2020; Marcus et al., 2010); further, the fat amount will result in MNA either underestimation or overestimation, depending on the situation of nutritional risk and thus is responsible for creating an imbalance in the estimation of the pathobiological risk. (Yen et al., 2024)

This study puts into perspective body fat composition as a modulator concerning MNA scores within a conceptual background involving pathobiological and pathomechanistic mechanisms of fat during aging. Different anthropometrical measures of adiposity and distribution of fat that explain how nutritional assessment outcomes may offer a better understanding of how fat composition may provide insight to explain nutritional and functional status, particularly in older persons-have been described. This, therefore, sets the basic components of fine-tuning in nutritional screening and in achieving a focus on an intervention regarding nutritional risks among an aging population.

2. METHODS

Study Design

This study examined 31 elderly at St. Francis of Assisi Catholic Church in 2024 through purposive sampling using a cross-sectional design. The inclusion criteria targeted female participants aged 60 and above who provided informed consent. Exclusion criteria were participants on medications that significantly impact body composition or nutritional status, such as high-dose corticosteroids, were excluded. Additionally, those with severe psychiatric disorders affecting their capacity to participate or adhere to study protocols were deemed ineligible, as individuals with severe mobility issues, as well as pregnant or lactating women, due to their unique nutritional and body composition needs.

Variables and Instruments

The MNA score obtained at 0-14 points assesses the nutritional status of the elderly. A score of 12-14 is the normal nutritional status, 8-11 is the risk of malnutrition, and 0-7 is malnutrition. The variables in the study are total body fat (%), visceral fat (%), basal metabolic rate (kcal/day), subcutaneous fat (%), and skeletal muscle (%), which spread in the various regions of the body. Body composition was measured using Omron Karada Scan HBF 375, calibrated following the standard protocol before the measurement.

Statistical Analysis

This study analyzed data using SPSS version 26 for quantitative univariate and bivariate data. Data normality was tested using the Shapiro-Wilk test. The correlation between body composition and MNA scores was analyzed using Spearman's Rho test. It is a non-parametric correlation test to determine the relationship between two data. The values were statistically significant at $p < 0.05$. The relationship between the two data was divided into trivial (0.00–0.10), weak (0.10–0.39), strong (0.40–0.69), very strong (0.70–0.89), and perfect (0.90–1.00). Respondent characteristics were expressed in the form of mean and standard deviation.

3. RESULT AND DISCUSSION

This study included 31 participants with an average age of 72.06 years (±6.6). The Mini Nutritional Assessment Score was 23.70 (±4.63). In the results of body composition, the mean total body fat was 37% (±5.05), visceral fat 9.98% (±6.32), the average BMI was 25.23 (±5.79), and the total skeletal muscle was 21.37% (±2.06), as detailed in Table 1.

Table 1. Characteristics of Research Results

Parameter	**Results**
Age	72.06 (6.6)
Mini Nutritional Assesment Score	23.70 (4.63)
Total Body Fat	37 (5.05)
Visceral Fat	9.98 (6.32)
Body Mass Index	25.23 (5.79)
Total Subcutaneous Fat	31.07 (6.47)
Trunk Subcutaneous Fat	27.87 (6.04)
Arm Subcutaneous Fat	47.45 (6.24)
Leg Subcutaneous Fat	39.79 (7.87)
Total Skeletal Muscle	21.37 (2.06)
Trunk Skeletal Muscle	15.18 (1.71)
Arm Skeletal Muscle	22.8 (3.73)
Leg Skeletal Muscle	34.2 (1.91)

In this study, the Shapiro-Wilk test was employed to assess the normality of the data distribution and revealed that all variables exhibited a non-normal distribution pattern. Spearman correlation demonstrates statistically significant correlations between the Mini Nutritional Assessment scores and several body composition parameters. Notable correlations were observed with body mass index ($r = 0.473$, $p = 0.007$), trunk subcutaneous fat ($r = 0.472$, $p = 0.007$), and visceral fat ($r = 0.457$, $p = 0.010$). Total subcutaneous fat ($r = 0.468$, $p = 0.008$) and arm subcutaneous fat ($r = 0.459$, $p = 0.009$) also showed significant correlations. Interestingly, arm skeletal muscle exhibited a negative correlation ($r = -0.486$, $p = 0.006$). These findings suggest that these body composition components are essential indicators of nutritional status in the elderly, highlighting that the determining factor of a good or poor MNA is fat composition. (Table 2)

Table 2. Correlation of Body Composition Components with Mini Nutritional Assessment Scores

Parameter	**Mini Nutritional Assessment**	
	r-correlation	**p-value**
Total Body Fat	0,446	0,012*
Visceral Fat	0,457	0,010*
Body Mass Index	0,473	0,007*
Total Subcutaneous Fat	0,468	0,008*
Trunk Subcutaneous Fat	0,472	0,007*
Arm Subcutaneous Fat	0,459	0,009*
Leg Subcutaneous Fat	0,465	0,008*
Total Skeletal Muscle	-0,130	0,485
Trunk Skeletal Muscle	-0,326	0,074
Arm Skeletal Muscle	-0,486	0,006*
Leg Skeletal Muscle	0,079	0,672
Age	-0,002	0,992

There are various changes with aging, including the distribution of body fat and loss of muscle mass or sarcopenia, which are major factors in altering body composition. (Dhillon & Hasni, 2017) These findings suggest that fat composition is an important determinant of the MNA score, which has been considered a good indicator of nutritional status in the elderly. Indeed, several fat-related parameters, such as total body fat, visceral fat, and regional subcutaneous fat on the trunk, arms, and legs, were significantly positively related to the MNA scores. This indicates that fat is an important reserve during nutritional stress, especially in elderly patients with malnutrition. Conversely, skeletal muscle parameters were significantly inversely related to MNA scores, especially arm skeletal muscle.

Sarcopenia may be defined as the progressive loss of skeletal muscle mass and strength, which often leads to a decline in physical functioning.(Cruz-Jentoft et al., 2010) At the same time, visceral increases result in a greater fat-to-muscle ratio. (Zhang et al., 2023) This redistribution can have negative health consequences because visceral fat is metabolically active and secretes inflammatory cytokines significantly more susceptible to inflammatory stress. Increased cellular senescence and the associated senescence-associated secretory phenotype (SASP) have been posited as hallmarks of aging and hypothesized to drive much of the functional decline in adipose tissue with age. (Birch & Gil, 2020; Ou et al., 2022; Starr et al., 2013) The general pathomechanism in the aging process involved the induction of TNF-α and IL-6 secretion via fat tissue and reduced expression of transcription factors implicated in adipogenesis. These latter changes can further contribute to an age-related decline in the capacity for lipid storage, as well as in insulin sensitivity by fat cells.

Later on, it might contribute to metabolic complications by causing systemic lipotoxicity.(Tchkonia et al., 2010) Brown fat generates heat production by mitochondrial oxidative phosphorylation. With aging, the content of brown fat is reduced, and preadipocytes are impaired.(Nirengi & Stanford, 2023; Tchkonia et al., 2010) Age-related visceral obesity partly originates from the suppression of PKA-dependent lipolysis during aging, facilitating lipid accumulation within the visceral fat tissue.(Tchkonia et al., 2010)

Oppositely, dysregulation of adipokines exerts additional control on appetite and energy expenditure and influences the inflammatory responses, thus creating a noxious circle promoting malnutrition.(Clemente-Suárez et al., 2023; Ou et al., 2022) Through the developed resistance to leptin, these hunger signals are impaired, leading to too little nutrition when sufficient or even excessive fat stores exist. (Arai et al., 2019) Conversely, low levels of adiponectin promote impairment in insulin sensitivity, enhancing catabolic processes that accelerate muscle degradation and further complicate the nutritional profile of the elderly.(Ou et al., 2022) Adiponectin regulates human longevity, potentially through maintaining insulin sensitivity and supporting mechanisms that counteract inflammation and oxidative stress associated with aging. (Arai et al., 2019)

It becomes difficult for older adults to achieve muscle mass as hormonal changes occur, such as the decline in estrogen levels. In females, menopause, generally between the ages of 45 and 52 years, is associated with a dramatic decline in both estradiol and progesterone. This change in the hormonal shift is associated with an acceleration of strength loss during this period of life. Muscle protein turnover and the ubiquitin-proteasome system are less active. Evidence has suggested that estrogen protects skeletal muscle by inhibiting apoptosis through modulation of heat shock protein and mitochondrial function. Thus, the lack of it triggers the processes of apoptosis, which are important to develop muscle loss.(Collins et al., 2019; Priego et al., 2021) This study represents the physiological difficulties of the elderly subjects in maintaining and regenerating muscle mass, worsened by hormonal changes, reduced muscle protein turnover, and low physical activity levels. As aging happens, vitamin D deficiency increases, specifically in skeletal muscle, causing decreased cell proliferation, regeneration, and muscle wasting.(Priego et al., 2021)

Malnutrition is especially problematic for the elderly because inadequate nutrition leads to loss of muscle mass and impairs fat metabolism.(Amarya et al., 2015; Norman et al., 2021; Susy et al., 2024) Consequently, older adults who do not get enough nutrients may have increased fat gain without the addition of lean muscle mass, thereby contributing to frailty and greater vulnerability to illness. (Moon et al., 2023)

Its findings, for a sample size of 31 participants, provide a platform to establish associations in the studied population cloak of providing a window for the conduct of further research with larger and more diverse groups so that it may serve to enhance generalisability. The cross-sectional design highlighted key associations that provide a springboard for longitudinal studies testing causation and change over time. This current study has also emphasized the need for further comprehensive studies, given that detailed data on dietary intake, physical activities and other lifestyle variables couldn't be fully captured.

4. CONCLUSION

This study underlined fat composition as important for nutritional status reflection, assessed through MNA scores, among elderly participants. Significant positive correlations of all fat-related parameters, such as BMI, total body fat, visceral, and subcutaneous fat concerning the MNA score, further underlined fat as a metabolic reserve in the face of nutritional stress. On the other hand, skeletal muscle parameters were primarily inversely related to arm muscle mass with the MNA score, showing that such features as sarcopenia and low levels of physical activity implicate aging. These findings underline the need for targeted intervention in optimizing fat distribution while preserving muscle toward better health outcomes in aging populations. Therefore, more research into such dynamics should be conducted among large and diverse groups.

REFERENCES

Alley, D. E., Ferrucci, L., Barbagallo, M., Studenski, S. A., & Harris, T. B. (2008). A Research Agenda: The Changing Relationship Between Body Weight and Health in Aging. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *63*(11), 1257–1259. https://doi.org/10.1093/gerona/63.11.1257

Al-Sofiani, M. E., Ganji, S. S., & Kalyani, R. R. (2019). Body composition changes in diabetes and aging. *Journal of Diabetes and Its Complications*, *33*(6), 451–459. https://doi.org/10.1016/j.jdiacomp.2019.03.007

Amarya, S., Singh, K., & Sabharwal, M. (2015). Changes during aging and their association with malnutrition. *Journal of Clinical Gerontology and Geriatrics*, *6*(3), 78–84. https://doi.org/10.1016/j.jcgg.2015.05.003

Arai, Y., Kamide, K., & Hirose, N. (2019). Adipokines and Aging: Findings From Centenarians and the Very Old. *Frontiers in Endocrinology*, *10*. https://doi.org/10.3389/fendo.2019.00142

Batsis, J. A., & Villareal, D. T. (2018). Sarcopenic obesity in older adults: aetiology, epidemiology and treatment strategies. *Nature Reviews Endocrinology*, *14*(9), 513–537. https://doi.org/10.1038/s41574-018-0062-9

Birch, J., & Gil, J. (2020). Senescence and the SASP: many therapeutic avenues. *Genes & Development*, *34*(23–24), 1565–1576. https://doi.org/10.1101/gad.343129.120

Clemente-Suárez, V. J., Redondo-Flórez, L., Beltrán-Velasco, A. I., Martín-Rodríguez, A., Martínez-Guardado, I., Navarro-Jiménez, E., Laborde-Cárdenas, C. C., & Tornero-Aguilera, J. F. (2023). The Role of Adipokines in Health and Disease. *Biomedicines*, *11*(5), 1290. https://doi.org/10.3390/biomedicines11051290

Collins, B. C., Laakkonen, E. K., & Lowe, D. A. (2019). Aging of the musculoskeletal system: How the loss of estrogen impacts muscle strength. *Bone*, *123*, 137–144. https://doi.org/10.1016/j.bone.2019.03.033

Cruz-Jentoft, A. J., Baeyens, J. P., Bauer, J. M., Boirie, Y., Cederholm, T., Landi, F., Martin, F. C., Michel, J.-P., Rolland, Y., Schneider, S. M., Topinková, E., Vandewoude, M., & Zamboni, M. (2010). Sarcopenia: European consensus on definition and diagnosis. *Age and Ageing*, *39*(4), 412–423. https://doi.org/10.1093/ageing/afq034

Dhillon, R. J. S., & Hasni, S. (2017). Pathogenesis and Management of Sarcopenia. *Clinics in Geriatric Medicine*, *33*(1), 17–26. https://doi.org/10.1016/j.cger.2016.08.002

Endo, Y., Nourmahnad, A., & Sinha, I. (2020). Optimizing Skeletal Muscle Anabolic Response to Resistance Training in Aging. *Frontiers in Physiology*, *11*. https://doi.org/10.3389/fphys.2020.00874

Marcus, R. L., Addison, O., Kidde, J. P., Dibble, L. E., & Lastayo, P. C. (2010). Skeletal muscle fat infiltration: Impact of age, inactivity, and exercise. *The Journal of Nutrition, Health and Aging*, *14*(5), 362–366. https://doi.org/10.1007/s12603-010-0081-2

Moon, S., Oh, E., Chung, D., Choi, R., & Hong, G.-R. S. (2023). Malnutrition as a major related factor of frailty among older adults residing in long-term care facilities in Korea. *PLOS ONE*, *18*(4), e0283596. https://doi.org/10.1371/journal.pone.0283596

Nirengi, S., & Stanford, K. (2023). Brown adipose tissue and aging: A potential role for exercise. *Experimental Gerontology*, *178*, 112218. https://doi.org/10.1016/j.exger.2023.112218

Norman, K., Haß, U., & Pirlich, M. (2021). Malnutrition in Older Adults—Recent Advances and Remaining Challenges. *Nutrients*, *13*(8), 2764. https://doi.org/10.3390/nu13082764

Ou, M.-Y., Zhang, H., Tan, P.-C., Zhou, S.-B., & Li, Q.-F. (2022). Adipose tissue aging: mechanisms and therapeutic implications. *Cell Death & Disease*, *13*(4), 300. https://doi.org/10.1038/s41419-022-04752-6

Palmer, A. K., & Jensen, M. D. (2022). Metabolic changes in aging humans: current evidence and therapeutic strategies. *Journal of Clinical Investigation*, *132*(16). https://doi.org/10.1172/JCI158451

Ponti, F., Santoro, A., Mercatelli, D., Gasperini, C., Conte, M., Martucci, M., Sangiorgi, L., Franceschi, C., & Bazzocchi, A. (2020). Aging and Imaging Assessment of Body Composition: From Fat to Facts. *Frontiers in Endocrinology*, *10*. https://doi.org/10.3389/fendo.2019.00861

Priego, T., Martín, A. I., González-Hedström, D., Granado, M., & López-Calderón, A. (2021). *Role of hormones in sarcopenia* (pp. 535–570). https://doi.org/10.1016/bs.vh.2020.12.021

Santanasto, A. J., Goodpaster, B. H., Kritchevsky, S. B., Miljkovic, I., Satterfield, S., Schwartz, A. V., Cummings, S. R., Boudreau, R. M., Harris, T. B., & Newman, A. B. (2016). Body Composition Remodeling and Mortality: The Health Aging and Body Composition Study. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, glw163. https://doi.org/10.1093/gerona/glw163

Santoso, A. H., Setiawan, F. V., Wijaya, B. A., & Destra, E. (2024). Pengukuran Komposisi Tubuh dalam Upaya Deteksi Obesitas pada Laki-laki dan Perempuan Usia Produktif di SMA Kalam Kudus II, Kelurahan Duri Kosambi, Jakarta. *KREATIF: Jurnal Pengabdian Masyarakat Nusantara*, *4*(2), 78–86. https://doi.org/10.55606/kreatif.v4i2.3359

Sayer, A. A., Syddall, H., Martin, H., Patel, H., Baylis, D., & Cooper, C. (2008). The developmental origins of sarcopenia. *The Journal of Nutrition, Health and Aging*, *12*(7), 427–432. https://doi.org/10.1007/BF02982703

Sowers, M., Zheng, H., Tomey, K., Karvonen-Gutierrez, C., Jannausch, M., Li, X., Yosef, M., & Symons, J. (2007). Changes in Body Composition in Women over Six Years at Midlife: Ovarian and Chronological Aging. *The Journal of Clinical Endocrinology & Metabolism*, *92*(3), 895–901. https://doi.org/10.1210/jc.2006-1393

Starr, M. E., Hu, Y., Stromberg, A. J., Carmical, J. R., Wood, T. G., Evers, B. M., & Saito, H. (2013). Gene expression profile of mouse white adipose tissue during inflammatory stress: age-dependent upregulation of major procoagulant factors. *Aging Cell*, *12*(2), 194–206. https://doi.org/10.1111/acel.12040

Susy Olivia Lontoh, Yohanes Firmansyah, Ernawati Ernawati, Santoso, A. H., William Gilbert Satyanegara, Bryan Anna Wijaya, Fiona Valencia Setiawan, Nicholas Setia, & Daniel Goh. (2024). The Relationship Between Physical Activity and Nutritional Status Based on Body Mass Index for Age Percentiles in Elementary School Children in Ciherang Village. *Archives of The Medicine and Case Reports*, *5*(3), 702–707. https://doi.org/10.37275/amcr.v5i3.553

Tchkonia, T., Morbeck, D. E., Von Zglinicki, T., Van Deursen, J., Lustgarten, J., Scrable, H., Khosla, S., Jensen, M. D., & Kirkland, J. L. (2010). Fat tissue, aging, and cellular senescence. *Aging Cell*, *9*(5), 667–684. https://doi.org/10.1111/j.1474-9726.2010.00608.x

Wilson, M.-M. G., & Morley, J. E. (2003). Invited Review: Aging and energy balance. *Journal of Applied Physiology*, *95*(4), 1728–1736. https://doi.org/10.1152/japplphysiol.00313.2003

Yen, C.-H., Lee, Y.-W., Chang, W.-J., & Lin, P.-T. (2024). The Mini Nutritional Assessment combined with body fat for detecting the risk of sarcopenia and sarcopenic obesity in metabolic syndrome. *British Journal of Nutrition*, 1–9. https://doi.org/10.1017/S0007114524000369

Zhang, S., Huang, Y., Li, J., Wang, X., Wang, X., Zhang, M., Zhang, Y., Du, M., Lin, J., & Li, C. (2023). Increased visceral fat area to skeletal muscle mass ratio is positively associated with the risk of cardiometabolic diseases in a Chinese natural population: A cross-sectional study. *Diabetes/Metabolism Research and Reviews*, *39*(2). https://doi.org/10.1002/dmrr.3597