Available online at : http://journal.unj.ac.id/unj/index.php/gjik
Gladi : Jurnal Ilmu Keolahragaan, 17 (04) 2026, 543-554
Permalink/DOI: https://doi.org/10.21009/GJIK.174.02

Association Between Body Mass Index and Flexibility in Obese Women: A Cross-Sectional Study

Arvyn Nabil Deviar Putra[1], Mohammad Arif Ali[1]*, Gustiana Mega Anggita[1], Sugiarto Sugiarto[1], Dewi Marfu'ah Kurniawati[2], Etika Ratna Noer[2], Alifya Nur Muhammad Laroibafih[1], Yofan Izdihar Lazuardi[1], Azkia Agustina[3]

[1] Department of Sports Science, Faculty of Sports Science, Universitas Negeri Semarang, Indonesia
[2] Department of Nutrition Science, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia
[3] Department of Public Health, Faculty of Public Health, Universitas Muhammadiyah Semarang, Indonesia

Corresponding author. Email **:** hiarifalikhan@mail.unnes.ac.id

(Submission Track: Received: 23-09-2026, Final Revision: 19-10-2026, Available Online: 11-11-2026)

Abstract. Flexibility is a key component in performing daily physical activities, including sitting, reaching for objects at height, engaging in exercise, and adapting to unexpected movements. Adequate flexibility is essential for maintaining functional independence in daily life. Conversely, individuals with reduced flexibility may experience difficulty in performing routine activities due to a limited range of motion, which restricts movement efficiency. However, findings from previous studies remain inconsistent. Some studies suggest that flexibility may be negatively affected by obesity, a condition characterized by excessive accumulation of body fat that can restrict joint movement and reduce range of motion, thereby influencing overall flexibility. Objective: The study aimed to evaluate flexibility levels in obese women and examine the association between BMI and flexibility.This is a quantitative descriptive correlational design with a cross-sectional approach. The purposive sampling technique was used to draw the subjects. Body mass index (BMI) was calculated based on measured body weight and height, while flexibility was evaluated using the sit-and-reach test. Pearson's correlation analysis was conducted using a significance threshold of 5%². Data were analyzed using Pearson's correlation test to examine the relationship between BMI and flexibility. Results: A total n=36 (100%) subjects were all obese. The flexibility levels of all subjects n=36 (100%) were at excellent (above 37 cm). Surprisingly, the correlation (r 0.034) between body mass index and flexibility level was not significant as $p < 0.05$. Conclusion: Obese women demonstrated excellent levels of flexibility; however, BMI showed no association with flexibility levels.

Keywords: *body mass index;flexibility;obese women;physical fitness*

Copyright © 2026 Arvyn Nabil Deviar Putra, Mohammad Arif Ali, Gustiana Mega Anggita, Sugiarto Sugiarto, Dewi Marfu'ah Kurniawati, Etika Ratna Noer, Alifya Nur Muhammad Laroibafih, Yofan Izdihar Lazuardi, Azkia Agustina
This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

INTRODUCTION

Physical fitness is essential for performing daily activities with ease. It includes flexibility, motor skills, cardiovascular fitness, and muscle strength (Ortega et al., 2018). Good physical fitness, or functional capacity, involves aerobic endurance, strength, balance, and flexibility, enabling safe daily activities without excessive fatigue (Martínez-Hernández et al., 2022). The 2024 SDI report in Indonesia shows that 55.5% of people aged 10–60 have poor or very poor fitness, while only 6.3% fall into the "good and above" category and 13.5% are moderate. Although slightly improved from 2023 (0.327 to 0.334), overall fitness remains very low, with lower participation among females across all age groups (Maksum & Kristiyanto, 2024).

The capacity to stretch is a crucial component of physical health that influences how far one can move. It pertains to how joints and muscles can operate without limitations throughout their complete motion range. This is essential for maintaining physical fitness and quality of life. However, flexibility naturally declines with age, affecting daily activities such as walking, bending, and reaching, while also increasing the risk of injury and reducing independence (Warneke, Wirth, et al., 2023). Another study show indicates that joint flexibility tends to decline with age, particularly in older adults (Martins, Tesio, Simone, Gonçalves, & Peyré-Tartaruga, 2023). This is supported by previous that aging can reduce older adults' ability to perform daily activities and maintain independence. This decline is influenced by factors such as loss of muscle mass, joint stiffness, and changes in connective tissue (Warneke, Wohlann, Lohmann, Wirth, & Schiemann, 2023).

Obesity is a significant factor in reduced flexibility. In the Asia-Pacific region, the WHO classifies BMI as follows: normal weight (18.5–22.9 kg/m²), overweight (23–24.9 kg/m²), and obesity class 1 (≥25.0 kg/m²). Obesity is a complicated long-term health issue marked by an overabundance of body fat that can impair muscle tissue and metabolic function (WHO, 2016). Demographic factors such as age, gender, and BMI also influence flexibility and lower-body function. Older individuals generally have lower levels of flexibility and balance in the lower extremities compared to younger individuals (Villareal, Apovian, Kushner, & Klein, 2005).

A previous study by Bittencourt et al. found that individuals with an abnormal BMI exhibit changes in flexibility. Increased fat mass and muscle shortening in overweight individuals can reduce hamstring flexibility. This shortening affects muscles such as the iliopsoas, hamstrings, gastrocnemius, quadriceps, piriformis, and pectoral muscles (Bittencourt

et al., 2017). Furthermore, overweight individuals may also experience reduced range of motion, particularly involving the hamstrings, including decreased hip flexion, hip extension, and plantar flexion (Silva, Muniz, Cerqueira, & Nadal, 2018). However, a study show suggests that overweight individuals do not necessarily experience reduced flexibility if they regularly perform stretching and engage in physical exercise (Jarral et al., 2021).

Given the inconsistent findings reported in previous studies, the researcher developed the following research questions: What is the level of flexibility among obese women, and is there a relationship between body mass index (BMI) and flexibility in this population? This study was conducted to provide a descriptive overview and to examine these associations. Specifically, it aims to assess the level of flexibility in obese women and to determine the relationship between BMI and flexibility. Ultimately, this study is expected to contribute empirical evidence toward understanding the relationship between BMI and obesity-related physical fitness outcomes.

METHOD

This research utilized a descriptive correlational quantitative method to analyze the connection between factors through numerical data evaluation. The main aim was to identify the link between Body Mass Index (BMI) and flexibility among women who are obese. A cross-sectional method was implemented, where data was gathered at one specific moment without any intervention, in order to describe the existing condition during the study period. In this study, BMI was defined as the independent variable, while flexibility was the dependent variable.

The study protocol was approved by the Institutional Ethics Committee of the Faculty of Medicine, Universitas Diponegoro. The target population consisted of women aged 34–65 years who were classified as obese women characterized by possessing a Body Mass Index (BMI) of 25 kg/m² or higher according to the WHO Asia-Pacific standards with normal (18.5 – 22.9), overweight (23–24.9), and obese (≥25) and resided in the vicinity of the study site. Inclusion criteria required participants to be capable of performing the sit-and-reach test, free from any current illnesses or functional impairments that could affect participation, non-smokers, non-drinkers, of Javanese ethnicity, and willing to provide written informed consent voluntarily without coercion. The phases of the study involved acquiring necessary authorizations, engaging with participants, assessing weight and height, and performing sit and reach assessments by qualified data collectors. Every measurement was documented on

observation forms for the study and checked for precision to ensure the reliability of the information.

A total of 36 participants meeting the inclusion criteria were recruited. Using a basic formula for correlation determined with a significance threshold ($p = 0.05$) and 80% power, it has been stated by (Barfield, 2018) that a minimum of 30 participants is necessary. In this research, the number of participants was 36, which fulfills the specified minimum requirement. Purposive sampling was used, with participants selected based on predefined criteria established by the researcher. Exclusion criteria included a history of or current injury to the hamstrings, hips, core, lower back, back, chest, or hands, the presence of neuromuscular pain, and the use of medications that may affect normal muscle function.

Flexibility was assessed using the sit-and-reach test following a standardized protocol. A ruler was positioned on a mat, and adhesive tape was placed across the ruler at the 38-cm mark. Participants were seated on the mat with the ruler positioned between the legs and the heels aligned at the 15-inch mark. With the legs separated by approximately 25–30 cm, participants were instructed to flex forward from the waist, lower the head, and reach forward as far as possible with one hand placed over the other (Julie Lohre, 2021) (Bushman, 2017). Participants then returned to the starting position, and the distance reached was recorded. The procedure was repeated up to three trials, and the highest value was recorded as the final score. Body Mass Index (BMI) is determined by taking an individual's weight in kilograms and dividing it by their height in meters squared. Weight readings were obtained with a Gea Medical 1623 EB9360 electronic scale, whereas height was assessed with a vertically installed microtoise. with a measurement range of 0–200 cm. All measurements were performed according to standard anthropometric procedures to ensure accuracy (Vagetti et al., 2017).

Statistical evaluation was performed utilizing IBM SPSS Statistics version 25. The Shapiro–Wilk test was employed to analyze data normality to identify the suitable correlation analysis method. The Pearson Product–Moment correlation test was used for data that followed a normal distribution, while the Spearman Rank correlation test (Spearman's rho) was applied for data that did not conform to a normal distribution. The threshold for statistical significance was established at $p < 0.05$. The strength of correlation was assessed using the correlation coefficient (r), categorized as follows: 0.00–0.09 (negligible), 0.10–0.39 (weak), 0.40–0.69 (moderate), 0.70–0.89 (strong), 0.90–0.99 (very strong), and 1.00 (perfect correlation).

RESULT AND DISCUSSION

Result

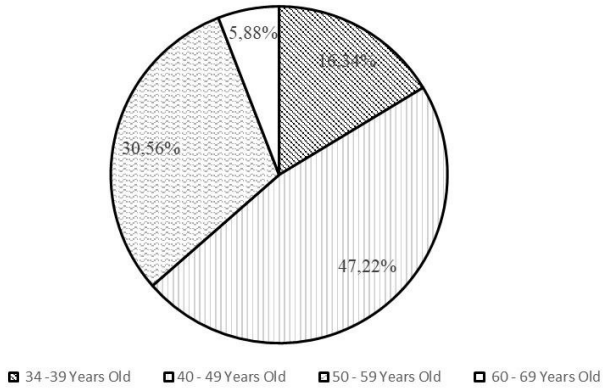


Figure 1. Age Classification of Subject

The study included a total of 36 participants, with ages ranging from 34 to 65 years, as illustrated in Figure 1. Based on the age classification of the Indonesian Ministry of Health (KEMENKES RI), participants were categorized into four age groups. The 34–39 years group consisted of 6 participants (16.34%), representing the third-largest proportion. The largest proportion was found in the 40–49 years group, with 17 participants (47.22%). This was followed by the 50–59 years group, which included 11 participants (30.56%). The smallest proportion was observed in the 60–69 years group, with 2 participants (5.88%).

The descriptive characteristics of the subjects are presented in the Table 1, including age, height, body weight, Body Mass Index (BMI), and flexibility. Body weight ranged from 56.80 kg to 90.40 kg, with a mean value of 71.66 ± 7.34 kg. BMI values ranged from 25.88 kg/m² to 43.94 kg/m², with a mean of 32.16 ± 4.21 kg/m². Flexibility scores ranged from 38 cm to 65 cm, with a mean value of 49.25 ± 7.40 cm.

Table 1. Characteristics of Subjects

Variables	n	Minimum	Maximum	Maximum
Age (years old)	36	34,00	65,00	47,97 ± 7,34
Weight (Kg)	36	56,80	90,40	71,66 ± 8,38
BMI (Kg/m2)	36	25,88	43,94	32,16 ± 4,21
Flexibility (cm)	36	38,00	65,00	49,25 ± 7,40

The BMI classification results (Table 2) indicate that all participants were categorized as obese. Specifically, none of the 36 participants (0.00%) fell within the underweight (<18.5 kg/m²), normal range (18.5–22.9 kg/m²), or overweight (23.0–24.9 kg/m²) categories. Conversely, all participants (36/36; 100%) were classified as obese (BMI > 25 kg/m²) (WHO,

2024) (Choi et al., 2019). These findings demonstrate a homogenous sample in terms of BMI status, as the entire study population consisted exclusively of individuals within the obese category.

Table 2. The Classification of Body Mass Index

BMI Classification (kg/m^2)	Ratio	Percentage
Underweight <18.5	0/36	0,00%
Normal Range 18.5 - 22.9	0/36	0,00%
Overweight 23.0 - 24.9	0/36	0,00%
Obese ≥25.0	36/36	100%

The results of the flexibility classification (Table 3) indicate that all participants demonstrated a high level of flexibility. Specifically, all 36 participants (100.00%) were categorized within the "Excellent" range (≥37 cm). No participants were classified in the "Above Average" (33–36 cm), "Average" (29–32 cm), "Below Average" (23–28 cm), or "Very Poor" (<23 cm) categories, each of which recorded 0 participants (0.00%) (Elizabeth Quinn,2024). These findings suggest a uniform distribution of flexibility scores within the highest classification level among the study participants, with no variation observed across the lower performance categories.

Table 3. The Classification of Flexibility

Flexibility Classification (cm)	Ratio	Percentage
Excellent: 37cm or above	36/36	100.00%
Above Average: 33-36cm	0/36	0.00%
Average: 29-32cm	0/36	0.00%
Below Average: 23-28cm	0/36	0.00%
Very Poor: Below 23cm	0/36	0.00%

The results of the Spearman's rho correlation analysis indicated a weak positive relationship between Body Mass Index (BMI) and flexibility. The correlation coefficient was r = 0.034 with a p-value of 0.422, suggesting a very weak association between the two variables that was not statistically significant. This finding reflects a positive direction of association, whereby an increase in BMI is accompanied by a slight increase in flexibility. However, based on the statistical test, no significant relationship was found between BMI and flexibility. Further details are presented in Table 04.

Table 4. The Correlation between BMI and Flexibility

Classification (cm)	BMI (kg/m^2)	
	r	*p*-value
Flexibility (cm)	0.034	> 0.05

Discussion

Based on the results of this study, the mean chronological age of the female participants was above 47 years. The findings further indicate that the majority of participants were classified as obese according to Southeast Asian Body Mass Index (BMI) classification standards, which define obesity as a BMI exceeding 25. The BMI results confirm that, on average, the participants fall within the obese category. This condition may be associated with a sedentary lifestyle, characterized by low levels of physical activity and limited awareness of regular exercise. Such a lifestyle may contribute to reduced muscle mass and decreased energy expenditure, thereby promoting excess caloric accumulation and subsequent obesity.

The correlation between BMI and flexibility was found to be very weak, suggesting that these variables are not directly associated. This weak relationship may be explained by the elevated BMI values, in which adipose tissue may obscure underlying muscle structures. As a result, the hamstring muscles (an important muscle group contributing to lower-extremity flexibility) may function sub-optimally due to the mechanical and structural constraints imposed by excess fat mass. This finding is consistent with previous studies reporting a significant association between increased BMI and reduced joint range of motion. Flexibility limitations are often attributed to anatomical and physiological alterations in musculoskeletal structures involved in movement, which may occur with advancing age and changes in BMI (Kuschner, O'connor, & Butz, 2017).

Furthermore, BMI has inherent limitations as it does not differentiate between fat mass, muscle mass, visceral fat, and subcutaneous fat. Instead, it provides a general estimation of nutritional status based on body weight (kg) and height (cm), which is subsequently converted into categorical classifications such as underweight, normal weight, overweight, and obese (Ramadany & Pasaribu, 2021). This limitation may partly explain the absence of a strong correlation between BMI and flexibility observed in this study. In relation to lower-extremity flexibility, the hamstring muscle group plays a crucial role and consists of three primary muscles: the biceps femoris, semitendinosus, and semimembranosus.

The increase in BMI observed in this study contrasts with the flexibility performance of adult female participants, as all participants demonstrated excellent flexibility scores. This finding differs from previous studies reporting reduced flexibility in obese women. For example, a study on obese women in the "*Idoso em Movimento*" program (an initiative promoting physical activity under the Municipal Secretariat for Sports and Recreation in Brazil)

found lower physical fitness levels, including poor performance in the chair sit-and-reach test, among overweight and obese participants. The study used probabilistic sampling with proportional random selection across districts (Vagetti et al., 2017).

Generally, higher BMI is associated with reduced flexibility and range of motion (ROM) due to excess adipose tissue mechanically limiting joint and muscle movement. However, this relationship may be mitigated by high levels of physical activity, which help maintain tissue elasticity and preserve muscle flexibility. Regular engagement of the hamstrings, hip joints, and pelvic region through stretching and movement-based activities may support flexibility, particularly in the lower extremities (Kaminski, Wabbersen, & Murphy, 1998).

Flexibility is also influenced by structural, hormonal, and behavioral factors. Women tend to have looser connective tissue and wider hip joints, while estrogen affects collagen properties, both contributing to greater ROM. In addition, women are more likely to participate in flexibility-enhancing activities such as yoga and dance. In this study, the good flexibility observed among obese women may be related to their active daily routines, which involve frequent use of key lower-limb muscle groups, including the hamstrings, gluteals, adductors, abductors, gastrocnemius, hip flexors, and quadriceps (Multani, Sutar, Nikhade, & Ghodey, 2019).

High flexibility scores are a key indicator of good physical fitness, suggesting that fitness is influenced not only by BMI but also by accumulated daily habits that sustain physical activity. Evidence shows that higher physical activity levels are strongly associated with improved flexibility. An intervention study demonstrated that participants who initially had no structured exercise program showed significant improvements after receiving a physical exercise intervention, including gains in lower-body flexibility. This supports the role of regular physical activity in enhancing flexibility, particularly among women (Pleticosic-Ramírez, Velarde-Sotres, Mecías-Calvo, & Navarro-Patón, 2024).

Results of the current study also highlights the limitations of BMI as a measure of body composition, as it reflects nutritional status without distinguishing between fat and muscle mass (Wiguna & Dewi, 2023). Supporting this, previous research reported a very strong correlation between BMI and body fat percentage ($r = 0.898$, $p < 0.001$) (Anggraini & Herviana, 2025). In addition, greater muscle strength contributes to slower age-related functional decline and helps maintain physical function (Chen et al., 2021). Findings of the current study also align with a long-term study of 3,139 middle-aged adults (2,087 men and 1,052 women aged 46–65 years)

assessed using the Clinimex Exercise Protocol over 13 years. The study found that higher Flex-index scores, indicating greater overall flexibility, were associated with better health outcomes even after adjusting for age, BMI, and health status (Pleticosic-Ramírez et al., 2024). It also reported that women had approximately 35% higher flexibility scores than men.

Authors also suggest that relatively good flexibility outcomes despite obesity may be associated with an apple-shaped fat distribution pattern. This is consistent with the findings of Faridah et al., which indicate that individuals with apple-shaped obesity tend to have a higher BMI than those with pear-shaped obesity due to greater fat accumulation in the abdominal and waist regions. Moreover, this obesity pattern has been reported to be associated with better flexibility compared to pear-shaped obesity (Faridah, Education, Negeri, & Info, 2021).

A key limitation of this study is the absence of a control group and the lack of a standardized flexibility exercise intervention, which limits the ability to determine whether structured training would have influenced the observed outcomes. Without a comparative group, it is not possible to isolate the effect of physical activity patterns on flexibility or to establish causality. In addition, the study sample was restricted to adult women classified as obese, which limits the generalizability of the findings to other populations, such as men, non-obese individuals, or different age groups.

However, there are some limitations of the given research that should be acknowledged. Firstly, the sample size of the research can be too small to draw any conclusive results. In addition, the research did not consider body composition parameters such as fat mass and muscle mass which would help understand how BMI relates to muscle strength. Almost all of the participants also work as farmers on a daily basis, which can affect their muscles while working. Furthermore, the design of the research does not allow to establish causal relationships between the variables. Thus, it is recommended to conduct future research with a larger sample size, better description of the participants' body composition, and longitudinal approach in order to deepen the knowledge about the relationship between BMI and muscle strength.

CONCLUSION

The findings indicate that participants demonstrated high levels of flexibility, with all subjects showing overall very good performance. The relationship between Body Mass Index (BMI) and flexibility among obese women was found to be weak, exhibiting a positive but statistically non-significant correlation. For future research, it is recommended that studies

include a larger sample size to improve statistical power and accuracy, involve a more diverse population to enhance generalizability, and incorporate prior exercise intervention protocols to further examine their potential effects on flexibility outcomes

ACKNOWLEDGMENTS

This study was conducted as part of a broader research project examining the adequacy of macronutrient intake in relation to metabolic syndrome parameters and physical fitness among individuals with type II diabetes mellitus, led by Mohammad Arif Ali. The authors gratefully acknowledge the contributions and support of all team members involved in the project. We also extend our sincere appreciation to all participants who actively took part in this study. This study was also funded by the Institute of Research and Community Service, Universitas Negeri Semarang, under Grant Number DPA LPPM UNNES No. DPA 139.032.693449/2025.01, Agreement Letter No. 61.14.3/UN37/PPK.11/2025.

REFERENCES

Anggraini, C. D., & Herviana, H. (2025). Hubungan Indeks Massa Tubuh Dengan Persen Lemak Tubuh Pada Mahasiswa. *Jurnal Kesehatan Tambusai*, *6*(4), 16731–16737. Retrieved from https://journal.universitaspahlawan.ac.id/

Barfield, C. (2018). *Administrators ' Perspectives and Strategies Regarding Student Homelessness*.

Bittencourt, A. dos S., Silva Vieira, P. A., Catarino Ferreira, M. C., Primo, L. L., Nara Deiro, T., Roberto Avelino, P., … Silveira Costa, H. (2017). The Impact of Overweight on Flexibility and Functional Capacity. *Journal of Novel Physiotherapies*, *07*(06). https://doi.org/10.4172/2165-7025.1000368

Bushman, B. A. (2017). *Complete Guide to Fitness & Health* (second edi). Retrieved from https://ebs.duzce.edu.tr/Uploads/DersMateryal/121116-8add26ab-adfb-4012-8701-d21a156f7e050.pdf?utm_source

Chen, H. H., Chen, H. L., Lin, Y. T., Lin, C. W., Ho, C. C., Lin, H. Y., & Lee, P. F. (2021). The associations between functional fitness test performance and abdominal obesity in healthy elderly people: Results from the national physical fitness examination survey in Taiwan. *International Journal of Environmental Research and Public Health*, *18*(1), 1–13. https://doi.org/10.3390/ijerph18010264

Choi, E., Cho, H. N., Seo, D. H., Park, B., Park, S., Cho, J., … Rhee, Y. (2019). *Socioeconomic inequalities in obesity among Korean women aged 19-79 years : the 2016 Korean Study of Women ' s Health-Related Issues*. 1–7

Elizabeth Quinn. (2024). What Is the Sit and Reach Test. https://www.verywellfit.com/sit-and-reach-flexibility-test-3120279?utm_source

Faridah, E., Education, P., Negeri, U., & Info, A. (2021). *Kinestetik : Jurnal Ilmiah Pendidikan Jasmani THE EFFECT OF OBESITY AND FLEXIBILITY TOWARD WOMEN ' S BODY FAT IN PRODUCTIVE AGE AT LARASATI GYMNASTIC SEMARANG MEMBER*. *5*(2), 266–275.

Jarral, S., Karim, S., Shehzadi, I., Malik, F., Rafaqat, A., Akram, M. J., & Junaid, M. (2021). Association of body mass index with flexibility in adults. *Ita. J. Sports Reh. Po*, *8*(18),

1892–1903. https://doi.org/10.17385/ItaJSRP.21.18.080302

Kaminski, T. W., Wabbersen, C. V., & Murphy, R. M. (1998). Concentric versus enhanced eccentric hamstring strength training: Clinical implications. *Journal of Athletic Training*, *33*(3), 216–221.

Kuschner, O'connor, & Butz, A. M. (2017). Addressing Obesity in Aging Patients. *Physiology & Behavior*, *176*(12), 139–148. https://doi.org/10.1016/j.mcna.2017.08.007.Addressing

Maksum, A., & Kristiyanto, A. (2024). *Laporan Indeks Pembangunan Olahraga 2024: Industri Olahraga Sebagai Sumber Pertumbuhan Ekonomi Baru*. Retrieved from https://www.researchgate.net/publication/387764033

Martínez-Hernández, B. M., Rosas-Carrasco, O., López-Teros, M., González-Rocha, A., Muñoz-Aguirre, P., Palazuelos-González, R., … Denova-Gutiérrez, E. (2022). Association between physical activity and physical and functional performance in non-institutionalized Mexican older adults: a cohort study. *BMC Geriatrics*, *22*(1), 1–11. https://doi.org/10.1186/s12877-022-03083-7

Martins, V. F., Tesio, L., Simone, A., Gonçalves, A. K., & Peyré-Tartaruga, L. A. (2023). Determinants of age-related decline in walking speed in older women. *PeerJ*, *11*, 1–18. https://doi.org/10.7717/peerj.14728

Multani, G. K., Sutar, A., Nikhade, N., & Ghodey, S. (2019). Effect of core strengthening on cardiovascular fitness and flexibility in obese individuals: experimental study. *International Journal Of Community Medicine And Public Health*, *6*(5), 2235. https://doi.org/10.18203/2394-6040.ijcmph20191850

Ortega, F. B., Cadenas-Sanchez, C., Lee, D., Ruiz, J. R., Blair, S. N., & Sui, X. (2018). Fitness and Fatness as Health Markers through the Lifespan: An Overview of Current Knowledge. *Progress in Preventive Medicine*, *3*(2), e0013. https://doi.org/10.1097/pp9.0000000000000013

Pleticosic-Ramírez, Y., Velarde-Sotres, Á., Mecías-Calvo, M., & Navarro-Patón, R. (2024). Can the Functional Physical Fitness of Older People with Overweight or Obesity Be Improved through a Multicomponent Physical Exercise Program? A Chilean Population Study. *Applied Sciences (Switzerland)*, *14*(15). https://doi.org/10.3390/app14156502

Ramadany, A., & Pasaribu, S. R. (2021). Pengaruh Indeks Massa Tubuh Terhadap Indeks Lengkung Telapak Kaki Mahasiswa Dan Mahasiswi Fk Uisu the Effect of Body Mass Index on Students Students of Fk Uisu. *Jurnal Kedokteran Ibnu Nafis*, *10*(2), 93–100.

Silva, F. R., Muniz, A. M. de S., Cerqueira, L. S., & Nadal, J. (2018). Biomechanical alterations of gait on overweight subjects. *Research on Biomedical Engineering*, *34*(4), 291–298. https://doi.org/10.1590/2446-4740.180017

Vagetti, G. C., Oliveira, V. de, Silva, M. P., Pacífico, A. B., Costa, T. R. A., & Campos, W. de. (2017). Association of body mass index with the functional fitness of elderly women attending a physical activity program. *Revista Brasileira de Geriatria e Gerontologia*, *20*(2), 214–224. https://doi.org/10.1590/1981-22562017020.160160

Villareal, D. T., Apovian, C. M., Kushner, R. F., & Klein, S. (2005). Obesity in older adults: Technical review and position statement of the American Society for Nutrition and NAASO, the Obesity Society. *Obesity Research*, *13*(11), 1849–1863. https://doi.org/10.1038/oby.2005.228

Warneke, K., Wirth, K., Keiner, M., Lohmann, L. H., Hillebrecht, M., Brinkmann, A., … Schiemann, S. (2023). Comparison of the effects of long-lasting static stretching and hypertrophy training on maximal strength, muscle thickness and flexibility in the plantar flexors. *European Journal of Applied Physiology*, *123*(8), 1773–1787.

https://doi.org/10.1007/s00421-023-05184-6

Warneke, K., Wohlann, T., Lohmann, L. H., Wirth, K., & Schiemann, S. (2023). Acute effects of long-lasting stretching and strength training on maximal strength and flexibility in the calf muscle. *German Journal of Exercise and Sport Research*, *53*(2), 148–154. https://doi.org/10.1007/s12662-022-00854-7

WHO. (2016). WHO Guidelines on physical activity and sedentary behaviour. In *Routledge Handbook of Youth Sport*. Retrieved from https://www.who.int/publications/i/item/9789240015128

World Health Organization. (2020). Obesity and Overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Wiguna, I. N. A. P., & Dewi, N. M. U. K. (2023). Hubungan Antara Indeks Masa Tubuh dan Tingkat Aktivitas Fisik Terhadap Fleksibilitas Otot Punggung Bawah dan Hamstring pada Siswa SMK Kesehatan Bali Kresna. *Jurnal Yoga Dan Kesehatan*, *6*(2), 189–200. https://doi.org/10.25078/jyk.v6i2.2918