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The Relationship Between Body Mass Index and Body Balance in Obese Women

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Abstract Obesity can affect body balance in women due to changes in weight distribution and shifts in the centre of gravity that reduce postural stability. This study aimed to determine balance levels and examine the relationship between Body Mass Index (BMI) and balance in obese women. A quantitative correlational design with a cross-sectional approach was used. Thirty-six obese women were selected through purposive sampling. BMI was calculated from weight and height, and balance was measured using the Stork Balance Test, recording the best of three trials. Pearson's correlation test was applied at a 5% significance level. The mean BMI was 32.15 ± 4.22 kg/m². The average balance time was 3.80 ± 2.40 seconds for the right leg and 3.46 ± 2.18 seconds for the left leg, both categorized as very poor (<5 seconds). A significant negative correlation was found between BMI and left-leg balance ($r = -0.347$; $p = 0.038$; 95% CI = −0.60 to −0.02), while no significant correlation was found for the right leg ($r = -0.188$; $p = 0.272$; 95% CI = −0.49 to 0.15). Higher BMI was associated with poorer balance only in the left leg, indicating a side-specific relationship. These findings support the need for balance and muscle-strengthening programs for obese women.

Keywords: Balance; Body Mass Index; Stork Balance Test; Women

INTRODUCTION

The aging process is a natural phase in human life characterized by various physiological, anatomical, and psychological changes. During this phase, the body's abilities begin to decline, including decreased muscle strength, bone density, nerve function, and the ability of the sensory and motor systems to maintain body balance. Body balance is a key ability for maintaining postural stability and is influenced by various physical factors, including Body Mass Index according to (Anita, Novitaria Marani, and Yusmawati 2021). One of the most common conditions in women is obesity or an increase in Body Mass Index (BMI) that exceeds normal limits. This condition not only affects physical appearance, but also has serious physiological consequences for posture, stability, and the ability to maintain balance.

According to the World Health Organization (2022), obesity is a condition of excessive body fat accumulation due to an imbalance between energy intake and expenditure. Obesity is generally measured using the Body Mass Index (BMI), which is calculated based on weight (kg) divided by height squared (m^2). Based on the WHO classification for the Asia-Pacific region, obesity begins at a BMI of ≥ 25 kg/m^2. An increase in BMI often occurs due to hormonal changes, particularly a decrease in estrogen levels prior to menopause. Estrogen plays an important role in regulating fat metabolism and adipose tissue distribution. This decrease in hormones causes fat accumulation in the abdomen and hips, altering the body's center of gravity and reducing the body's ability to maintain dynamic balance. (Paweł, Wiesław, and Cies 2017).

Data from (Sartoyo, Anis Ansyori, Paulla Roro Pratiwi 2024) shows that the prevalence of obesity in women over the age of 40 reaches 37.2%, higher than that of men in the same age group. In Central Java, the obesity rate among pre-elderly women is also quite high, at 31.6% of the total population aged 45–59 years (DINKES JATENG 2023). Tegal Regency is one of the areas with an increasing trend in obesity cases. The main contributing factors are a lifestyle that tends to be physically inactive, high consumption of fatty and simple carbohydrate foods, and a lack of awareness of the importance of physical activity. The impact of obesity on body balance has been proven by previous studies. Body balance is an individual's ability to maintain their posture so that their center of gravity remains within their base of support, both when stationary (static balance) and when moving (dynamic balance). Acording to (Kinansi et al. 2023),

body balance is controlled by a sensory integration system involving the vestibular, visual, and proprioceptive systems. When body weight increases excessively, the distribution of body mass becomes uneven, causing changes in posture and gait. The body must work harder to maintain balance, especially when making posture changes such as standing, walking, or turning.

Research conducted by (Fazhladia As'syura , Firdawati , Asterina , Dwi Yulia , Liganda Endo Mahata 2021) in Sumenep Regency found a significant relationship between BMI and dynamic balance in the elderly, with a p-value of 0.004 and a correlation coefficient of r = 0.604. These results indicate that the higher a person's BMI, the greater the disturbance to their dynamic balance. Older adults with obesity tend to take longer to complete the Time Up and Go Test (TUG), which indicates an increased risk of falling (Beauchet et al. 2011)**.** Researchers explain that excess fat accumulation affects the strength of the lower extremity muscles, especially the thigh and calf muscles, which play an important role in maintaining postural stability.

Similar research by (Sartoyo, Anis Ansyori, Paulla Roro Pratiwi 2024) at the Pesona Desa Karangrejo Kediri Elderly Health Center also showed that there was a significant relationship between overweight and obesity and dynamic balance, with a significance value of p = 0.000 (<0.05). Subjects with a BMI in the obesity category had a higher risk of falling compared to the overweight or normal groups. Interestingly, this study also found that women showed a greater tendency to experience a decline in balance compared to men, because their muscle mass is generally lower and neuromuscular adaptation to postural changes tends to be slower. Meanwhile, (Ni Made Rika Puriyanti, M Widnyana, I Made Krisna Dinata 2023) in their study in Canggu Village, Bali, found that obesity is closely related to a decline in static and dynamic balance in the elderly. Subjects with obesity had significantly lower balance scores compared to subjects with normal BMI. This study explains that excess body fat causes increased load on the musculoskeletal system and proprioceptive disturbances that play a role in detecting body posture. This proprioceptive imbalance causes a delay in the body's response to changes in posture, leading to postural instability. (Fazhladia As'syura , Firdawati , Asterina , Dwi Yulia , Liganda Endo Mahata 2021) adds a new perspective on the relationship between BMI and metabolic disorders, finding that an increase in BMI correlates with high blood glucose levels. Chronic hyperglycemia can affect the function of the peripheral nervous

system, including the nerves that regulate proprioception and movement coordination. As a result, obese individuals not only experience mechanical disorders of the musculoskeletal system, but also neurophysiological disorders that exacerbate body instability. This reinforces the understanding that obesity not only adds to the body's mechanical load, but also disrupts the nerve communication necessary to maintain balance.

From an anatomical and biomechanical perspective, an increase in BMI causes the body's center of gravity to shift forward, especially in individuals with abdominal fat accumulation. This shift requires greater work from the lower back, pelvic, and leg muscles to maintain an upright posture. In the long term, this muscle fatigue can reduce postural ability and increase the risk of falls, especially in obese women who begin to experience muscle weakness due to degenerative processes. (Beauchet et al. 2011). Kelemahan otot ekstremitas bawah menjadi salah satu penyebab utama gangguan keseimbangan, khususnya pada kelompok usia lanjut dan pra lansia yang kurang melakukan aktivitas fisik (Sumarni, Rosidin, and Witdiawati 2025). This phenomenon is important to note because balance disorders due to obesity can directly impact a person's quality of life, daily mobility, and functional independence. Individuals with obesity who have balance disorders are at greater risk of falls, fractures, or head trauma, which can further reduce their participation in social and economic activities.

Thus, research on the relationship between BMI and body balance in obese women is highly relevant and important, because obesity rates continue to increase. Through this research, it is hoped that an empirical picture can be obtained regarding the extent of body balance in obese women and whether there is a relationship between BMI and body balance in obese women. The aim is to determine the level of body balance in obese women and to find out the relationship between BMI and body balance in obese women. The results can be used as a basis for health workers, especially in the fields of sports and physiotherapy, to design effective muscle strengthening and balance training programs for obese women. In addition, the results of this study are also expected to be taken into consideration in the planning of health promotion policies at the regional level, through elderly health center activities, routine BMI checks, and education on the importance of a healthy lifestyle and weight control.

METHODS

This study is a descriptive correlational quantitative study that aims to determine the relationship between Body Mass Index (BMI) and body balance in obese women. The research design used is cross-sectional, where data collection is carried out at one time to see the relationship between the two variables without intervention.

The target population for this study was all obese women residing in Blubuk Village, Tegal Regency. Data collection was carried out using purposive sampling, with the following inclusion criteria: obese women who were able to stand and walk without assistive devices, and who were willing to participate by signing a consent form. Exclusion criteria included subjects with a history of lower limb injury, or those taking medication that affects the central nervous system. Based on a simple correlation formula calculation with a significance level ($p = 0.05$) and 80% power, According to the (Barfield 2018), the minimum sample size required is 30. In this study, the sample size consisted of 36 respondents, thus meeting the required minimum.

The independent variable in this study was Body Mass Index (BMI), while the dependent variable was body balance. Weight was measured using a GEA Medical 1623 EB9360 digital scale and height was measured using a GEA Medical microtoise. BMI was calculated using the formula of body weight (kg) divided by height squared (m^2). BMI categories refer to the WHO Asia Pacific classification, namely: normal (18.5–22.9), overweight (23–24.9), and obese (≥25).

Body balance was measured using the Stork Balance Test, a commonly used method for assessing static balance that has demonstrated good validity and reliability in previous studies (Kitsao-Wekulo et al. 2013), The procedure involves the subject placing the sole of their right foot on the outer side of their left knee, with both hands on their hips. The subject stands on the toes of their supporting foot for as long as possible; conversely, once they are on their toes, the duration is recorded (Ardi, Hidayatullah, and Anwar 2022). The time was taken using a Joyko SW-500 stopwatch. The value used in this study was the best value from three trials according to (Kitsao-Wekulo et al. 2013). The assessment was given using the norms from Arnot R and Gaines C in 1984, namely with the following classifications: more than 35 seconds is in the very good category, 25-34 seconds is in the above average category, 15-24 seconds is in the average category, 6-

14 seconds is in the below average category, and below 5 seconds is in the very poor category.

Data analysis was performed using SPSS version 26.0. The Shapiro–Wilk test was used to determine the type of correlation test to be used. If the data were normally distributed, the Pearson Product Moment test was used, whereas if the data were not normally distributed, the Spearman Rank test (Spearman Rho) was used. A p-value < 0.05 was considered to indicate a significant relationship between BMI and body balance. The interpretation of the correlation strength refers to the r value: 0.00–0.199 (very weak), 0.20–0.399 (weak), 0.40–0.599 (moderate), 0.60–0.799 (strong), and 0.80–1.00 (very strong).

The ethical aspects of the study included written consent from the subjects (informed consent), confidentiality of participant identities, and assurance of no physical or psychological risks during the research process. This study obtained official permission from local educational and health institutions prior to implementation. The study was conducted in July 2025. The research stages included obtaining permits, socializing with participants, measuring weight and height, and conducting balance tests by trained enumerators. All measurement results were recorded on research observation sheets and verified to ensure data accuracy.

RESULTS AND DISCUSSION

This section presents the results of data analysis, including a description of subject characteristics such as age, weight, and height. Data normality tests and correlation tests between Body Mass Index (BMI) and body balance were also conducted. The analysis was performed using SPSS version 26 with a significance level of $p = 0.05$. All results were then interpreted based on previous theories and research to explain the relationship between BMI and body balance ability in obese women.

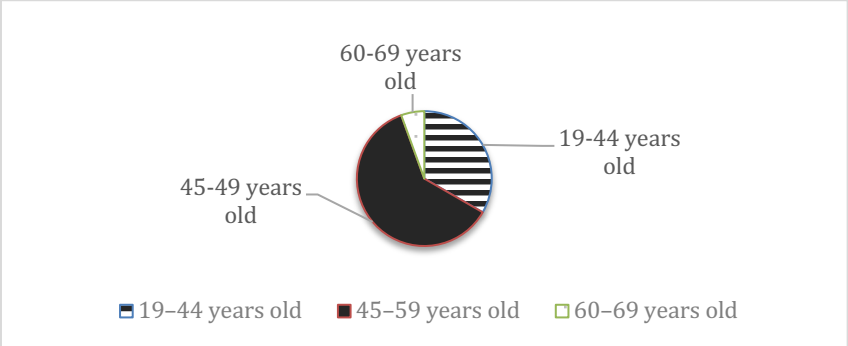

Figure 1. Age distribution of subjects

The age distribution of subjects provides an overview of the age range included in this study. Age can affect physical condition, including hand muscle strength, because biological factors such as muscle mass and metabolic function tend to change with age (Palmer and Jensen 2022)**.** Subjek dalam penelitian ini berjumlah 36 orang perempuan dengan karakteristik demografis menunjukkan rata-rata usia 46,97 tahun. There were 36 female subjects in this study with demographic characteristics showing an average age of 46.97 years. Based on this average age, the subjects can be categorized as pre-elderly. This category refers to the standard from the Indonesian Ministry of Health (PERMENKES RI TAHUN 2019), which defines the pre-elderly age range as 45 to 59 years. Detailed data can be seen in Figure 1.

Based on the results of descriptive analysis of 36 subjects, it was found that the participants' weight ranged from 56.80 kg to 90.40 kg, with an average of 71.66 kg. This figure shows that the majority of participants weighed around 70 kilograms. The standard deviation value of 8.38 indicates a clear variation in weight between individuals. For the Body Mass Index (BMI) variable, the values obtained ranged from 25.88 to 43.94, with an average of 32.16. Referring to the BMI categories, this average value indicates that most subjects were in the obese category, because a BMI ≥ 30 is included in that category. (Taieb et al. 2022). The standard deviation of 4.22 shows that the participants' BMI tended not to vary greatly, so that their weight was relatively similar between subjects. The subjects' height ranged from 139 cm to 158 cm, with an average of 149.44 cm. The standard deviation value of 4.48 shows that the height differences between participants were still within the normal range and not too striking. Overall, these data show that the participants' physical characteristics tended to be homogeneous in terms of height, but varied more in terms of weight and BMI. Detailed data can be seen in Table 1.

Tabel 1. Descriptive Statistics Tabel

Variabel	**N**	**Minimum**	**Maximum**	**Mean**	**± Std. Deviation**
Weight (kg)	36	56,80	90,40	71,66	±8,38
Height (cm)	36	139,00	158,00	149,44	±4,48
Body Mass Index (Kg/m^2)	36	25,88	43,94	32,16	±4,22

The descriptive analysis results show that the right leg variable values for 36 subjects ranged from 0.00 to 10.34, with an average of 3.80. The standard deviation value of 2.40 indicates that there is considerable variation between subjects in terms of right leg ability or scores. This means that the participants' performance on the right leg was uneven and tended to vary. The left leg variable had a value range of 0.00 to 9.74, with an average of 3.46. This average value was slightly lower than the right variable, so it can be concluded that the ability or score on the left leg tended to be slightly below that of the right leg. The standard deviation of 2.18 indicates that the variation in scores for the left leg is also quite large, but slightly smaller than for the right leg. Both variables show a similar pattern with the same minimum value, a fairly wide range, and clear individual variation. However, the performance of the right foot appears to be slightly better than the left foot based on the higher average value. The average balance of the right foot is slightly higher (3.80 seconds) than the left (3.46 seconds), but the difference is not statistically significant. The average value between the right and left legs is (3.80+3.46):2 = 3.63 seconds. According to the norms of Arnot R and Gaines C in 1984, these results indicate that the level of balance in obese women is very poor because it shows an average value below 5 seconds. Detailed data can be seen in Table 2.

Tabel 2. Average balance of the right and left legs

Variabel	N	Minimum	Maximum	Mean	± Std. Deviation	Category
Right leg (second)	36	0,00	10,34	3,8008	±2,40296	Very poor
Left leg (second)	36	0,00	9,74	3,4561	±2,17594	Very poor

The relationship between BMI and right leg balance showed a correlation value r = –0.188 (p = 0.272) 95% CI = −0,49 to 0,15) indicating no significant relationship, while the left leg showed r = –0.347 (p = 0.038) 95% CI = −0,60 to −0,02), indicating a significant negative relationship. This indicates that the higher the BMI, the lower the balance ability, especially on the left leg. The negative correlation value indicates that obesity can have an impact on decreased postural control. These results are in line with research (Ni Made Rika Puriyanti, M Widnyana, I Made Krisna Dinata 2023) which found that an increase in BMI in the elderly correlates with a decrease in static balance ability. Excess body fat, especially in the abdomen and hips, causes the body's center of gravity to shift anteriorly, thereby increasing postural instability. Uneven weight distribution adds stress to the musculoskeletal system, especially the lower extremity

muscles that play a role in maintaining balance. This may explain why balance on the left leg is more impaired than on the right leg, as the non-dominant leg usually has lower muscle stability. Complete data can be seen in Table 3.

Tabel 3. Results of the correlation test between BMI and body balance

Variabel	**BMI**	**Kg/m^2**
	r	***p-Value***
Balance right leg	–0.188	0.272
Balance left leg	–0.347	0.038

Obesity affects body balance symmetrically, not just on one leg. According to (Fazhladia As'syura , Firdawati , Asterina , Dwi Yulia , Liganda Endo Mahata 2021) in obese individuals, body fat accumulation tends to spread bilaterally in the pelvic area and lower extremities, so that an unbalanced distribution of weight affects both legs. As a result, both the right and left legs experience a decrease in their ability to support body weight stably. Previous research has also shown that quadriceps muscle strength and range of motion have a significant effect on static balance (Leonda et al. 2020).

The findings of this study indicate a negative correlation between Body Mass Index (BMI) and body balance ability in obese women, particularly in the left leg. These results reinforce the theory that excessive weight gain can cause a decline in motor skills, impaired postural control, and an increased risk of body imbalance. (Batista et al. 2021) Although no significant difference was found between right and left balance, the negative correlation value on the left leg indicates that body mass distribution and muscle weakness in the non-dominant leg can worsen overall body stability. This indicates that body balance is greatly influenced by muscle strength and an individual's physical condition. Previous research has also shown that balance is related to physical fitness components such as lower-body muscle strength, which plays a role in maintaining body stability (Leonda et al. 2020).

Physiologically, obesity causes an increase in mechanical load on the musculoskeletal system. This additional load increases the torque on the knee, ankle, and hip joints, requiring the body to exert more effort to maintain posture. This condition increases the workload on the muscles that support the body, especially the gastrocnemius, quadriceps, and gluteus medius muscles, which play an important role in

maintaining static balance when standing on one leg. An increase in BMI causes biomechanical changes in the body in the form of a shift in the center of gravity forward, which causes the body's corrective response to balance disturbances to be slower. According to (Ni Made Rika Puriyanti, M Widnyana, I Made Krisna Dinata 2023).

The results of this study also support the findings of (Sartoyo, Anis Ansyori, Paulla Roro Pratiwi 2024) which state that individuals with high BMI have poorer muscle coordination and postural reflexes than individuals with normal weight. The imbalance between muscle strength and body weight causes a loss of optimal neuromuscular control. In the long term, this can lead to proprioceptive degradation, namely a decrease in the body's ability to recognize posture and joint movement. This condition is one of the main causes of static and dynamic balance disorders in obese women.

From a neurological perspective, (Fazhladia As'syura , Firdawati , Asterina , Dwi Yulia , Liganda Endo Mahata 2021) adds that obesity is often associated with metabolic disorders such as insulin resistance and increased blood glucose levels, which can potentially affect the function of the peripheral nervous system. Disorders of the peripheral nerves, especially in the lower extremities, can reduce the body's ability to detect changes in posture, thereby slowing down reflex responses when the body loses balance. Thus, the higher a person's BMI, the greater the likelihood of disorders in the proprioceptive system and postural reflexes. In addition to weight, the aging process also plays an important role in reducing balance ability. With age, there is a decrease in muscle elasticity, a reduction in muscle mass (sarcopenia), and degeneration of the vestibular and visual systems. The combination of obesity and aging creates a double condition that burdens the body's control system against gravity.

The results of this study have important implications for preventing the risk of falls in obese women. Impaired balance can have a negative impact on daily activities such as walking, standing for long periods, climbing stairs, and even social activities. When these abilities are impaired, the quality of life and independence of obese women will also decline. Therefore, efforts to maintain an ideal body weight through a balanced diet and regular physical exercise are highly recommended. Exercises such as tai chi, yoga, or proprioceptive balance training have been shown to strengthen core muscles and improve body stability. Thus, this study confirms that BMI is an important factor affecting body balance in obese women. Increased BMI not only impacts metabolic and

cardiovascular aspects but also reduces neuromuscular function, which plays a role in maintaining static balance. Therefore, weight control and strengthening of lower extremity muscles are key strategies for preserving motor function and reducing the risk of falls in obese women.

CONCLUSION

The balance level of obese women in this study was categorized as very poor. A negative relationship between BMI and body balance was observed, with a significant correlation found only in the left leg, indicating a side-specific effect. An increase in BMI may increase mechanical load, shift the center of gravity forward, and require greater effort from the lower extremity muscles to maintain balance. These findings suggest that obese women have a higher risk of impaired balance, particularly in the left leg.

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