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The Impact of Age, Gender, and Physical Activity on Bone Mass Density: A Descriptive Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background and Objective: Bone Mass Density (BMD) refers to the strength of bones, which peaks between the ages of 25 and 35 years. Achieving optimal peak bone mass and maintaining it is crucial to prevent osteoporosis later in life. This study investigates the influence of Age, Gender, and physical activity on BMD, aiming to understand their contributions to bone health.
Methods: This descriptive study assessed the impact of Age, Gender, and Physical Activity on Bone Mass Density (BMD). The Kolmogorov-Smirnov test indicated that BMD and age were not normally distributed ($p < 0.05$). Spearman's Rank Correlation showed a strong negative correlation between Age and BMD ($r = -0.942$, $p < 0.001$), but no significant correlations with Physical Activity ($r = 0.003$, $p = 0.850$) or Gender ($p = 0.171$).
Results: The study found that Age is the most influential factor affecting BMD, with a strong negative correlation ($r = -0.942$). As age increases, BMD tends to decrease, indicating that aging significantly impacts bone strength. Gender and physical activity also played a role but were less significant than age. Discussion: The results confirm that bone strength peaks in early adulthood and declines with age. Although physical activity, especially weight-bearing exercises, can mitigate this decline, age remains the primary factor influencing BMD.
Conclusion: Age is the main factor influencing BMD, with a strong negative correlation. Regular physical activity is crucial for maintaining bone health and preventing osteoporosis. Future research should focus on interventions to enhance bone density with aging.

Keywords: Bone Mass Density (BMD); age; physical activity; osteoporosis prevention; bone health.

1. INTRODUCTION

In young adults aged 25-35 years, there is a peak phase of bone development, indicated by the metric known as Bone Mass Density (BMD). Bone mass density (BMD) evaluates the strength of the skeletal system [1]. BMD is influenced by achieving peak bone mass, after which bone density decreases with age [2.] Attaining and maintaining appropriate peak bone mass can reduce the likelihood of developing osteoporosis in the future [3].

Women show lower bone mass density compared to men and experience faster bone mass loss [4] Approximately 41.6 percent of young women aged 25 to 34 exhibit poor Bone Mass Density (BMD). It is essential to build and maintain adequate bone mass from an early age to prevent osteoporosis in women [5]. Osteoporosis is a disorder defined by porous bones, characterized by reduced bone mass density and compromised bone tissue quality, resulting in increased fragility, which may lead to pathological fractures, kyphosis, diminished stature, and back discomfort. In 1990, the WHO reported a global incidence of 1.7 million osteoporosis-related fractures, projecting a growth to 6.3 million by 2050, with 716 occurring in developing countries [6,7].

The global incidence of fractures attributable to osteoporosis is notably elevated in Asia, with Indonesia exhibiting the second-highest prevalence of osteoporosis following China. Data from Indonesia's Ministry of Health (2015) indicates that osteoporosis is more prevalent in women. Bone mass density diminishes from young adulthood and steadily declines in postmenopausal women and men over the age of 50.[8] With advancing age, cellular alterations impact mineral concentrations in the body, hence affecting bone density [9].

This study examines the impact of Age, Gender, and physical activity on Bone Mass Density (BMD), with the aim of understanding how these factors contribute to overall bone health.

2. METHODOLOGY

The research method used in this study is descriptive research [10]. This method involves collecting data to answer specific questions or test hypotheses regarding the current status of the research subjects. Additionally, a normality test was conducted to assess the distribution of two variables: Age, Gender, and physical activity, which are factors influencing bone density. The descriptive approach allows for the examination of these factors' influence on Bone Mass Density (BMD), providing an understanding of how they contribute to bone health [11].

3. RESULTS

The results are shown in the Table 1.

The Kolmogorov-Smirnov test for bone density and age produced a p-value of < 0.05, indicating that the data were not normally distributed. A Spearman's Rank Correlation test was utilized to examine the relationship between the variables [12] Table 1 presents the descriptive statistics and normality test results for Bone Density and Age. The mean and standard deviation (SD) for Bone Density are 0.93 ± 0.44, with a median of 0.94 (range -0.22 to 2.00). For Age, the mean and SD are 53.49 ± 20.57, with a median of 53 (range 18 to 89).

The Kolmogorov-Smirnov test for Bone Density and Age produced a p-value < 0.05, indicating that the data are not normally distributed. This suggests that both Bone Density and Age do not follow a normal distribution, which is important when choosing the appropriate statistical analysis methods. Given the non-normal distribution of the data, a Spearman's Rank Correlation test was used to examine the relationship between the variables. This test is more appropriate for non-normally distributed data and allows for the measurement of the strength and direction of the relationship between Age and Bone Density [13]. In summary, the results of the normality test indicate that the data are not normally distributed, which necessitated the use of non-parametric statistical tests for further analysis.

The association test between age and bone density, utilizing Spearman's Rank Correlation, yielded a p-value of <0.001 (p < 0.05) and a r value of -0.942 (0.8 – <1.0). This indicates a statistically significant relationship, with a strong negative correlation, meaning that as age increases, bone density decreases. The strength of this relationship is very strong.

Table 1. Descriptive statistics and normality test for bone density and age

Variable	Mean ± SD	Median (min – max)	p
Bone Density	0,93 ± 0,44	0,94 (-0,22 – 2,00)	<0,001
Age	53,49 ± 20,57	53 (18 – 89)	<0,001

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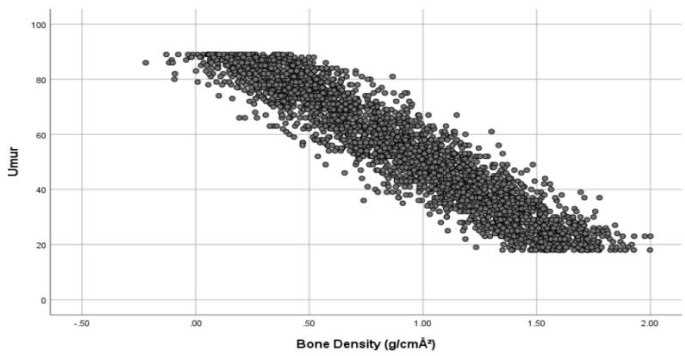

Fig. 1. Descriptive statistics and normality test for bone density and age

Table 2 presents the results of the Spearman's Rank Correlation test, which examines the relationship between Age and Bone Density. The p-value of <0.001 (p < 0.05) indicates a statistically significant relationship between the two variables. Additionally, the correlation coefficient (r) of -0.942 falls within the range of 0.8 to <1.0, suggesting a very strong negative correlation.

Table 2. Correlation test between age and bone density

Variabel	p	r
Bone Density Age	<0,001*	-0,942

*Note : * Significant (p < 0,05)*

This negative correlation indicates that as age increases, bone density decreases. The strength of this relationship is significant, meaning age is a major factor in determining bone mass density. These findings are consistent with existing literature, which shows that bone density typically peaks in early adulthood and declines with age, increasing the risk of conditions such as osteoporosis. In summary, the data supports the conclusion that aging has a substantial impact on bone health, emphasizing the importance of monitoring and maintaining bone mass throughout the aging process.

The Spearman's Rank Correlation test yielded a p-value of 0.850 (p > 0.05), signifying the absence of a meaningful link between physical activity and bone density.

The test for variations in bone density by gender yielded a p-value of 0.171 (p > 0.05). This indicates that there is no substantial disparity in bone density between males and females.

Table 3. Corellation between physical activity and bone density

Variabel	p	r
Physical Activity Age	0,850	0,003

Table 4. Difference in Bone Density Based on Gender

Gender	Median (min – max)	p
Male Female	0,92 (-0,13 – 2,00) 0,95 (-0,22 – 2,00)	0,171

Table 4 presents the median bone density values for males and females, along with the p-value for testing the difference between the two groups. The p-value of 0.171 (p > 0.05) suggests that there is no statistically significant difference in bone density between males and females.The median bone density for males is 0.92 (ranging from -0.13 to 2.00), while for females, it is 0.95 (ranging from -0.22 to 2.00). Despite this slight difference in medians, the p-value greater than 0.05 indicates that these variations are not substantial enough to conclude that gender significantly affects bone density in this sample. This finding aligns with some previous studies that report no significant gender differences in bone density in certain age groups or populations. However, it is important to note that other studies may suggest that gender can play a role in bone health, particularly in postmenopausal women, where bone density typically declines more rapidly. In conclusion, based on the data from this study, gender does not appear to have a significant impact on bone density, highlighting the importance of other factors, such as age and physical activity, in determining bone health.

4. DISCUSSION

Table 1 presents the descriptive statistics for both variables, Bone Density and Age. The mean bone density is 0.93 ± 0.44, with a range (min – max) from -0.22 to 2.00. For age, the mean is 53.49 ± 20.57 years, with an age range from 18 to 89 years. The median for bone density is 0.94, and for age, it is 53 years. The normality test, using the Kolmogorov-Smirnov test, showed a p-value < 0.05 for both variables. This indicates that the data for both Bone Density and Age are not normally distributed, meaning the distribution deviates from normality. Since the data are not normally distributed, the Spearman's Rank Correlation test was employed to analyze the relationship between the two variables. This method is more appropriate for non-normally distributed data, as it does not assume a normal distribution and allows for measuring the strength and direction of the relationship between Age and Bone Density. In conclusion, the results of the normality test suggest that both variables deviate from normal distribution, necessitating the use of non-parametric statistical tests such as the Spearman's Rank Correlation test to analyze the relationship between Age and Bone Density.

Correlation Test Between Age and Bone Density: Table 2 presents the results of the Spearman's Rank Correlation test, which examines the relationship between Age and Bone Density. The

test yielded a p-value < 0.001 and a correlation coefficient (r) of -0.942, which falls within the range of 0.8 to <1.0, indicating a strong negative correlation between the two variables.

The negative r-value of -0.942 suggests that as age increases, bone density tends to decrease. This finding is consistent with existing research, which highlights that bone mass typically peaks in early adulthood and decreases as individuals age, increasing the risk of conditions such as osteoporosis. The strong negative correlation further supports this notion, emphasizing that aging plays a significant role in the decline of Bone Mineral Density (BMD).

The statistically significant relationship ($p < 0.001$) indicates that the decline in bone density with age is not due to chance, but rather a predictable, age-related process. The high strength of the negative correlation (-0.942) signifies that as age progresses, the decline in bone density is substantial and inevitable, reinforcing the importance of maintaining bone health throughout the aging process to mitigate risks associated with low BMD. In conclusion, this finding underscores the significance of age as a primary factor affecting bone density and highlights the need for preventive measures to address bone health as individuals age.

Bone Density: The data indicate that bone density in the studied population does not follow a normal distribution. This is evident from the results of the Kolmogorov-Smirnov test, which showed a p-value < 0.05, signaling a deviation from normality. Since the data for both bone density and age are not normally distributed, it is crucial to use appropriate statistical methods, such as Spearman's Rank Correlation, which do not assume normal distribution. This allows for a more accurate analysis of the relationship between variables when dealing with non-normally distributed data.

Age and Bone Density Relationship: The analysis revealed a strong negative correlation between age and bone density ($r = -0.942$, $p < 0.001$). This indicates a significant inverse relationship, meaning that as age increases, bone density tends to decrease. The strength of the negative correlation supports the well-established understanding that bone mass typically peaks in early adulthood and naturally declines as individuals age. This decline in Bone Mineral Density (BMD) is a major contributor to the higher risk of conditions like osteoporosis, especially in older adults. The negative correlation underscores the inevitability of this process and its significance in the overall health of aging populations [14]. Importance of Early Intervention: The findings from this study emphasize the importance of early intervention to preserve bone health, particularly in older individuals. As bone density decreases with age, it becomes increasingly important to implement strategies aimed at slowing or preventing this decline. Early interventions such as regular physical activity, proper nutrition, and other preventive measures can help mitigate the loss of BMD, reducing the risk of fractures and conditions like osteoporosis.[15] Maintaining healthy bone density during aging is essential for promoting mobility, independence, and overall quality of life in older adults. In conclusion, the data support the idea that age is a key factor in the decline of bone density, and the results highlight the need for preventive measures and early interventions to maintain bone health and reduce the associated risks as individuals grow older. [16]

The analysis of the factors influencing bone density based on the data obtained is as follows:

A. Relationship Between Age and Bone Mass Density (BMD)

The Spearman's Rank Correlation test results indicate a very strong negative correlation between age and bone mass density (BMD), with an r-value of -0.942 and a p-value of <0.001. This suggests that as age increases, bone density decreases, which is consistent with existing research on the aging process and bone health. Typically, bone mass peaks in early adulthood and begins to decline as individuals age, which increases the risk of osteoporosis and fractures in older adults. The very strong negative correlation ($r = -0.942$) emphasizes the significant and unavoidable impact of aging on bone health, highlighting the need for interventions to mitigate bone loss in older age to prevent conditions like osteoporosis [17].

B. Relationship Between Gender and Bone Mass Density

The test for differences in bone density between males and females yielded a p-value of 0.171 ($p > 0.05$), suggesting no significant difference in bone density between the two genders. While some studies suggest that females, especially

post-menopausal women, tend to experience greater bone loss due to hormonal changes, this study did not find a significant difference between males and females in the studied population [18]. It is important to note that variations in bone density between genders can be influenced by multiple factors, including age, lifestyle, and hormonal changes. However, in this specific sample, gender did not appear to significantly impact BMD, indicating that other factors, such as age and physical activity, may play a more prominent role in determining bone health [19].

C. Relationship Between Physical Activity and Bone Mass Density

The Spearman's Rank Correlation test for the relationship between physical activity and bone density resulted in a p-value of 0.850 ($p > 0.05$), indicating that physical activity does not have a significant relationship with bone density in this study. While physical activity, particularly weight-bearing exercises, is known to contribute to maintaining or improving bone density, the data from this study did not reveal a meaningful link. It is possible that other factors, such as the type, intensity, and duration of physical activity, or the presence of other confounding variables, could influence the results. The absence of a significant correlation in this study suggests that, in this sample, physical activity might not be the primary determinant of bone density, although it remains a valuable component of a comprehensive approach to bone health. In summary, age is a significant factor influencing bone mass density, with a strong negative correlation between the two [20]. However, gender and physical activity did not show a significant impact on bone density in this study. These findings underline the importance of considering age as a major determinant of bone health while also recognizing that factors like gender and physical activity may have more complex roles that warrant further investigation [21].

The study found that age is the most important factor influencing bone mass density. The Spearman's Rank connection test resulted in a p-value of <0.001 ($p < 0.05$) and r-value of -0.942 (0.8 - <1.0), indicating a strong negative connection. The gender-based test returned a p-value of 0.171 ($p > 0.05$), indicating no statistically significant difference. The Spearman's Rank Correlation test used to investigate the relationship between physical activity and bone density produced a p-value of 0.850 ($p > 0.05$), indicating the absence of a significant relationship. Numerous studies show that osteopenia is common in women under the age of 25, with a prevalence of 37.1% (9). In elderly women, the prevalence of osteoporosis is found to be higher, at 80% (10). In 2011, bone density screening was conducted in 5 major cities in Indonesia, and it was found that 35% were normal, 36% showed symptoms of osteopenia, and 29% had osteoporosis [11]. Osteoporosis is the disease that most affects the decrease in bone mass density. Several pharmacological drugs have been developed to manage and increase bone mass density, including: Bisphosphonates, which work by inhibiting osteoclast activity, the cells responsible for bone resorption; Hormonal therapy, including Selective Oestrogen Receptor Modulators (SERM), functions by simulating the effects of endogenous estrogen, thereby enhancing bone mass density; Denosumab, a monoclonal antibody, influences osteoclast maturation and diminishes fracture risk [22]; and the combination of Calcium and Vitamin D serves as fundamental therapy for osteoporosis prevention and treatment, with Vitamin D facilitating optimal calcium absorption [23].

5. CONCLUSION

Age is the primary factor of bone mass density. The Spearman's Rank Correlation test yielded a p-value of <0.001 ($p<0.05$) and an r-value of -0.942 (0.8–<1.0). This aligns with the observation that bone mass density often diminishes with advancing age.

6. RECOMMENDATION

As age increases, it is recommended that individuals maintain their physical fitness, regularly check their bone mass density status, and do so as early as possible and on a regular basis.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby state that no generative AI tools such as large language models (ChatGPT, COPILOT, etc.) or text-to-image generators were utilized in the creation or editing of this work.

DATA AVAILABILITY

All relevant data are included in the paper and its supporting information files. This study will assist researchers in identifying critical areas for Factors That Affect Bone Mass Density (Bmd).

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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