Original Article

Lean Body Mass, Body Fat Percentage, and Handgrip Strength as Predictors of Bone Mineral Density in Postmenopausal Women

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Submitted: 06-Feb-2021
Revised: 22-Jul-2021
Accepted: 08-Dec-2021
Published: 20-Jan-2022

ABSTRACT

Objective: This study was conducted to assess lean body mass, body fat percentage, and handgrip strength in the prediction of bone mineral density (BMD) in postmenopausal women. **Materials and Methods:** This cross-sectional study included 102 postmenopausal women aged between 45 and 80 years (mean age 58) who were screened for osteoporosis using a dual-energy X-ray absorptiometry scan at the lumbar spine. The lean body mass, body fat percentage, and handgrip strength were calculated. **Results:** The lean body mass, body fat percentage, and handgrip strength were having a positive association (correlation coefficient: 0.48, 0.29, and 0.3, respectively) with BMD. **Conclusion:** Lean body mass, body fat percentage, and handgrip strength can detect early loss of BMD in postmenopausal women leading to early screening for osteoporosis resulting in early interventions minimizing BMD loss over a much longer period after menopause.

Keywords: *Bone mineral density, handgrip, lean body mass, osteoporosis, postmenopausal*

Introduction

Osteoporosis was defined as "a generalized bone disease characterized by a decreased bone mass and a deterioration of bone microarchitecture resulting in an increased fracture risk."[1] For epidemiological purposes, osteoporosis has been defined as a bone mineral density (BMD) lower than − 2.5 standard deviation below the mean peak BMD in young healthy adults of the same gender, also known and expressed as the T-score.[2] BMD is used as a measurement tool for the early identification of individuals at high risk of a fracture related to osteoporosis.[3]

Estrogen deficiency after menopause is associated with an increase in bone turnover, resulting in bone mineral loss with increased chances of osteoporotic fracture.[4] Rapid loss of BMD occurs after menopause which is believed to average approximately 2%–3% every year.[5] Postmenopausal osteoporosis is associated with significant morbidity and mortality as a result of increased fragility fractures.[6]

As a consequence of menopause and aging, peak bone mass is reduced in women. A higher percentage of lean body mass boosts our metabolism serving as a protective factor against bone fractures. Maintaining body fat percentage at a certain level is essential for optimum functioning of the body. In postmenopausal women, the strength of muscles decreased leading to the inability of bones to withstand the biomechanical forces increasing fracture risk.[7]

Most studies report that either lean mass or fat mass is associated with bone mass,[8-12] whereas Harris *et al*. indicated that both fat mass and lean mass can equally serve as a predicting factor for BMD.[13] Kim *et al*. made an observation that lean mass was associated with BMD in both pre- and postmenopausal women.[14] Cheung *et al*. reported a strong concomitant decline in both muscle strength and BMD with advancing age.[15]

Owing to the presence of conflicting findings in the association of lean mass, fat mass, and muscle strength to BMD, in this study, we try to find out lean body mass, body fat percentage, and muscle strength as predictors of BMD in postmenopausal women.

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Access this article online

Quick Response Code:

Website: www.jmidlifehealth.org

DOI: 10.4103/jmh.jmh_21_21

How to cite the article: Prakash KO, Choudhary R, Singh G. Lean body mass, body fat percentage, and handgrip strength as predictors of bone mineral density in postmenopausal women. J Mid-life Health 2021;12:299-303.

Materials and Methods

Study design

A total of 102 postmenopausal women aged between 45 and 80 years participated in this cross-sectional study conducted from September 2019 to August 2020. The inclusion criteria were women aged >45 years with a menopause duration of at least 1 year. Women with chronically debilitating conditions, having systemic disease affecting metabolism, having severely deformed or fractured spine, previous osteoporotic fracture, on long-term steroid therapy, and medications causing osteoporosis were excluded from the study. Enrollment in the study was done after taking written informed consent. The study was approved by the Institutional Ethics Committee. General demographic and relevant clinical history was taken.

Anthropometric and body composition measurement

Weight was measured in kilograms and height in centimeters using a standardized procedure. Body mass index (BMI) was calculated by standardized formula. The body fat % was calculated by using a formula that converts BMI into an estimate of body fat %:

$$\text{Body fat \%} = (1.39 \times \text{BMI}) + (0.16 \times \text{Age}) - (10.34 \times \text{Gender}) - 9$$

With gender equal to 1 for men and 0 for the woman (International Journal of Obesity and Related Metabolic Disorders in 2002). For calculating lean body mass, body fat percentage was subtracted from 100 to get the lean mass percentage and lean mass percentage was divided by 100 to calculate the decimal for lean mass percentage, and then lean mass decimal was multiplied with total body weight.

Bone mineral density measurement

BMD was measured using dual-energy X-ray absorptiometry at the lumbar spine as a mean of measured values from L1 to L4 spine and was analyzed using software, and the report was presented in the form of a T-score. Osteoporosis was defined as a T-score ≤2.5, low bone mass as T-score between −1.0 and −2.5, and normal as a T-score >−1.

Muscle strength measurement

The handgrip strength was measured with the help of the handgrip dynamometer to measure the maximum isometric strength of the hand and the muscle of the forearm. The subject was seated in a chair without armrests, with feet fully resting on the floor and the hips and knees positioned at approximately 90° with shoulder adducted with elbow flexed to 90° with the forearm in mid-prone position and wrist in 15° and 30° of extension and 0°–15° of ulnar deviation. Three successive measurements were taken, with a 15-s interval between them, selecting the best score out of the three measurements.[16]

Statistical analysis

The values of variables were calculated as a percentage, mean, and standard deviation. Correlation analysis of T-score with age, weight, height, body mass index, body fat percentage, lean body mass, and handgrip strength was done to obtain Pearson's correlation. Multiple linear regression analysis was used to obtain the predictors for the outcome variable. Associations were considered statistically significant at $P < 0.05$ level. All statistical analyses were performed using SPSS statistics version 26 (IBM Co., Armonk, NY, USA).

Results

Table 1 shows the baseline, anthropometric, and body composition characteristics of the 102 women studied. Among 102 postmenopausal women, 23.5% were normal, 46.1% had osteopenia, and 30.4% had osteoporosis, respectively, as per the WHO criteria. More than 75% of the study population was having low BMD (osteopenia and osteoporosis). In our study, low BMD was found in the early menopausal period up to 50 years and age >65 years. In our study, high BMI was associated with higher BMD values.

Women were categorized as par body fat percentage into underweight, healthy, overweight, and obese with prevalence of osteoporosis 6.5 % in underweight, 64.5 % in healthy, 22.6 % in overweight and 6.5 % in obese respectively. Body fat percentage was positively associated (correlation coefficient: 0.29) with BMD. As the body fat percentage is increased, T-score also increased suggesting a decreased prevalence of low mineral density, as shown in Figure 1 plotted as a regression variable.

The study population was divided into three categories as per lean body mass into <40, 40–45, and >45

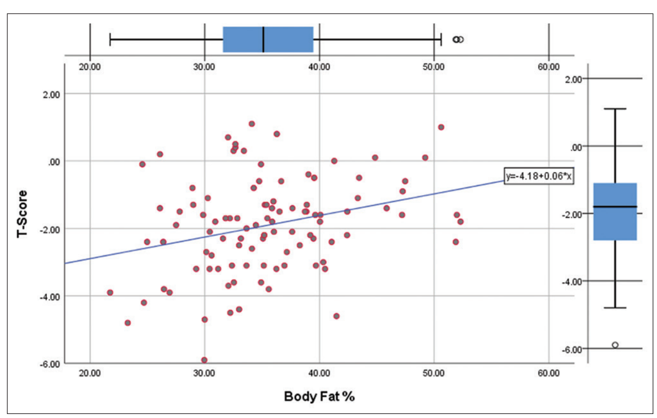

Figure 1: Regression variable plots body fat percentage versus T-score

with 35.5%, 45.2%, and 19.4% osteoporotic women, respectively, in each category with more than 80% values falling in below 45. The data suggest a positive correlation (correlation coefficient: 0.48) of lean body mass with BMD, as shown in Table 2. As shown in Figure 2 plotted as regression variable, as the lean body mass is increased, T-score also increased so that the prevalence of low BMD is decreasing.

The data on handgrip strength were divided into good, average, and poor, with 51.6% of women with poor handgrip. There was a positive correlation of BMD with handgrip strength (correlation coefficient: 0.30).

In Figure 3 plotted as regression variable, as handgrip strength is increased, T-score also increased suggesting higher BMD in women with good handgrip strength.

Discussion

The results of this study show that there is a positive association between body fat percentage, lean body mass, and handgrip strength with BMD in postmenopausal women. Previous studies show an age-dependent decline in BMD, especially in elderly women due to cortical and trabecular bone loss.[17-20] We also found a positive association between advanced age and the occurrence of osteoporosis. Previously, it was believed that women with low BMI are at increased risk of developing osteoporosis, but in our study, a higher body mass index was associated with high BMD which coincides well with recent studies showing overweight and obesity as protective factors against future osteoporotic fractures.[21,22]

Epidemiological studies have suggested that body fat percentage may affect bone mass status, especially in the aged group. The effect of metabolically active adipose tissue on the bone or skeleton may be regulated by both weight-bearing and nonweight-bearing effects.[8,9]

Previous studies have reported a positive association of obesity with bone mass, probably as a result of an increased level of hormones such as insulin, leptin, and estrogen that are known bone growth inducers and bone remodeling process inhibitors which coincides with our study findings showing strong positive association of body fat percentage with BMD.[23-25]

Lean mass is the strongest predictor of BMD in our study which coincides well with studies; higher lean body mass was associated with lower future fracture risk.[26-28] In this study, both lean mass and body fat percentage were predictors of BMD in comparison to

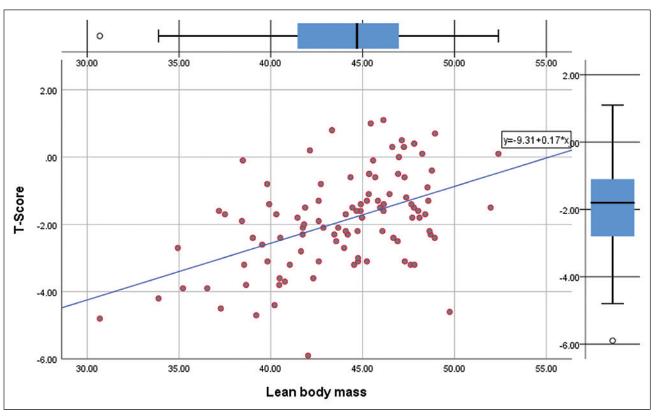

Figure 2: Regression variable plots lean body mass versus T-score

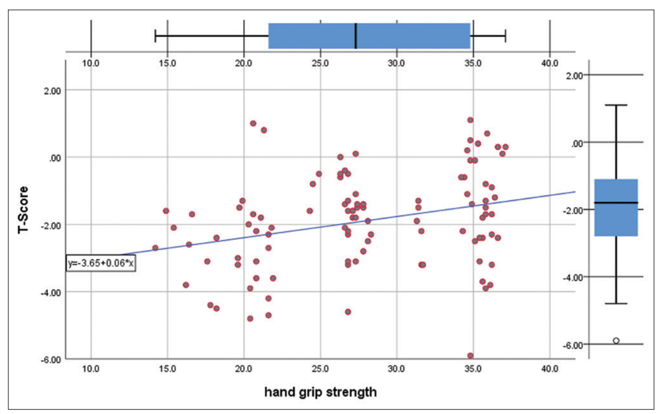

Figure 3: Regression variable plots handgrip strength versus T-score

Table 1: Baseline, anthropometric, and body composition characteristics (*n*=102)

	Statistic						
	Range	Minimum	Maximum	Mean		SD	Variance
				Statistic	SE		
Age	40	45	85	58.46	0.923	9.317	86.805
T-score	7.00	−5.90	1.10	−1.9020	0.13980	1.41190	1.993
Height (m)	0.15	1.60	1.75	1.6538	0.00302	0.03048	0.001
Weight (kg)	60	40	100	69.24	1.236	12.479	155.726
BMI	21.11	15.63	36.73	25.2993	0.44360	4.48014	20.072
Body fat (%)	30.55	21.74	52.30	35.5198	0.63902	6.45378	41.651
Lean body mass	21.70	30.69	52.39	43.8867	0.39722	4.01175	16.094
Handgrip strength	22.9	14.2	37.1	27.835	0.6588	6.6537	44.272

SE: Standard deviation, BMI: Body mass index, SD: Standard deviation

Table 2: Pearson correlations of different parameters (*n*=102)

	T-score	Age	Height (m)	Weight (kg)	BMI	Body fat (%)	Lean body mass	Handgrip strength
T-score								
P correlation	1	−0.276	0.228	0.399	0.369	0.293	0.479	0.296
Significant (two-tailed)		0.005	0.021	0.000	0.000	0.003	0.000	0.003
Age								
P correlation	−0.276	1	−0.099	0.016	0.035	0.265	−0.286	−0.946
Significant (two-tailed)	0.005		0.324	0.870	0.727	0.007	0.004	0.000
Height (m)								
P correlation	0.228	−0.099	1	0.236	0.035	0.011	0.510	0.114
Significant (two-tailed)	0.021	0.324		0.017	0.729	0.914	0.000	0.256
Weight (kg)								
P correlation	0.399	0.016	0.236	1	0.979	0.948	0.873	0.023
Significant (two-tailed)	0.000	0.870	0.017		0.000	0.000	0.000	0.815
BMI								
P correlation	0.369	0.035	0.035	0.979	1	0.973	0.792	0.004
Significant (two-tailed)	0.000	0.727	0.729	0.000		0.000	0.000	0.970
Body fat (%)								
P correlation	0.293	0.265	0.011	0.948	0.973	1	0.698	−0.215
Significant (two-tailed)	0.003	0.007	0.914	0.000	0.000		0.000	0.030
Lean body mass								
P correlation	0.479	−0.286	0.510	0.873	0.792	0.698	1	0.304
Significant (two-tailed)	0.000	0.004	0.000	0.000	0.000	0.000		0.002
Handgrip strength								
P correlation	0.296	−0.946	0.114	0.023	0.004	−0.215	0.304	1
Significant (two-tailed)	0.003	0.000	0.256	0.815	0.970	0.030	0.002	

BMI: Body mass index

studies showing either body fat percentage or lean mass as a predictor of BMD.

In this study, handgrip strength is associated with BMD which correlated well with a similar cross-sectional study confirming the association of poor handgrip strength as a predictor of future fracture risk.[15] These findings were supported by a cross-sectional study conducted among the Finnish postmenopausal women and documented a significant association between handgrip strength and hip fracture, a serious consequence of low BMD.[29]

The shortcomings of this study were its cross-sectional design and single-site BMD measurement. A long-duration follow-up study with a large number of subjects with three sites BMD measurement will further elaborate the findings of this study.

Conclusion

Lean mass, body fat percentage, and handgrip strength parameters can detect early loss of BMD in postmenopausal women leading to early detection of osteoporosis resulting in early interventions minimizing BMD loss over a much longer period after menopause. Hence, it is recommended that postmenopausal women with low lean body mass, low body fat percentage, and low handgrip strength go through early screening for BMD loss and take therapeutic intervention to reduce future fracture risk.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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