Research Article

The Relationship between Body Composition and Bone Mineral Density of Female Workers in A Unit of Tai’an

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Objective. To explore the relationship between body composition and bone mineral density (BMD) of female workers in a university of Tai’an. Methods. This study randomly selected 90 female employees in a university of Tai’an. The body composition was monitored by body composition analyzer (inbody770), and the lumbar bone mineral density was monitored by dual energy X-ray absorptiometry (BMD model). The data were analyzed by SPSS 22.0 statistical software. Results. With the increasing of body mass index (BMI), BMD of female lumbar spines 1-4 (L1-4) increased gradually. Spearman correlation analysis showed that BMI, skeletal muscle mass, upper limb muscle mass, trunk muscle mass, lower limb muscle mass, and whole-body phase angle were positively correlated with L1-4BMD. Age was negatively correlated with L1-4BMD. Linear regression analysis showed that age was a negative factor of L1-4BMD, and skeletal muscle mass was a protective factor of abnormal bone mass, especially lower limb muscle mass. Conclusions. Lower limb muscle mass is a protective factor of female BMD. Strengthening physical exercise to improve lower limb muscle mass is conducive to the prevention of female osteoporosis.

1. Introduction

The aging population in China has been dramatically growing, which becomes a heavy burden for the government at all levels. In addition to the common metal diseases such as Alzheimer’s disease and Parkinson’s disease [1, 2], an increasing attention is paid to the physical diseases.

Osteopenia/osteoporosis (OP) is a metabolic bone disease mainly caused by aging, which is associated with gradual changes in body composition [3–6]. By means of the long-standing bone mass reduction and bone microstructure destruction, OP is making the appendicular bone brittler and brittle, which is prone to fracture. There are many known and potential driving factors influencing OP, for instance, the intake of vitamin D, hormone level, and sex-specific metabolic diseases [4]. Thus, the whole progression is entirely different between men and women [7, 8]. The population with abnormal bone mass in women is significantly higher than that in men [9], especially in postmenopausal women [4, 10]. As a hotspot, the association has been widely concerned between bone mineral density (BMD) and aging, body weight, nutritional status, smoking, alcohol, physical activity, etc. [11–13]. However, the research conclusions regarding the contribution to the adequate maintenance of BMD cannot reach a consensus [14–23]. Reid et al. took the lead in demonstrated that fat mass (FM), one main component of the body weight, is closely related to fat mass in premenopausal women [19]. Next year, the Framingham study stated that weight or BMI is much more strongly associated with BMD in elder women and men as a load factor [24]. Further, Dimitri et al. believed that obesity is a protective against fracture based on their study [25]. For postmenopausal women, Mpalaris and his colleagues proposed a U-bend curve to illustrate the relationship between BMI and the fracture risk [26]. For children, neither the diagnostic criteria is uniform nor the decision of therapy as well as therapeutic efficacy comes to reach agreement [8, 25, 27–32]. What is worse, the acataleptic
relationship between body composition and BMD affects the diagnosis and treatments of the patients with other complex diseases [33–38].

The study conducted here is aimed at checking if different assemblies of body components may play different roles in bone metabolism. Should the further study on the correlation between body composition and bone health help to guide women to prevent and treat osteoporosis and improve their life quality?

2. Objects and Methods

2.1. Research Objects. Female employees of one university who had routine physical check-ups in the examination center of the Second Affiliated Hospital of Shandong First Medical University from January 2021 to May 2021 were finally included as the research objects. They had not participated in formal vocational physical exercise and voluntarily accepted DEXA monitoring bone mineral density and body composition analysis. Finally, 90 cases were included, aged 37–85 years, with an average of (54.84 ± 7.88) years. This study was approved by the ethics committee of the Second Affiliated Hospital of Shandong First Medical University, and all subjects signed informed consent. Specific inclusion criteria were as follows: (1) no disease affecting bone metabolism (thyroid disease, Xin syndrome, etc.); (2) no drugs affecting bone metabolism and body composition (glucocorticoid, estrogen, thyroid hormone, parathyroid hormone, calcitonin, diphosphate, etc.); (3) no serious liver and kidney diseases; (4) do not drink alcohol; and (5) no history of tumor.

2.2. General Data Collection. The subjects were fasting, took off their shoes, bareheaded, wearing single clothes, measured their weight (kg) and height (cm), and calculated their BMI. The calculation formula was as follows: weight (kg) divided by the square of height (m²). Based on the BMI grouping standard formulated by the working group on obesity in China (WGOC) and the guidelines in references [3, 5], the cohort with 18.5 ≤ BMI < 24 kg/m² is the normal weight group, while the cohort with BMI ≥ 24 kg/m² is the overweight/obese group.

2.3. Body Composition Test. Use the body 770 body composition tester to test the body composition of the subjects. The test indexes include waist hip ratio, muscle mass (kg), fat mass (kg), body fat percentage (%), upper limb muscle mass (kg), trunk muscle mass (kg), lower limb muscle mass (kg), upper limb fat mass (kg), trunk fat mass (kg), lower limb fat mass (kg), whole-body phase angle (°), and visceral fat area (cm²).

2.4. Bone Mineral Density Test. According to the Chinese expert consensus about the diagnosis of osteoporosis [39], the bone mineral density of lumbar spines 1-4 (L1-4) was tested by dual energy X-ray bone mineral density tester (Primus, OSTO, Korea) [40].

2.5. Statistical Analysis. The SPSS v22.0 statistical software is used for data analysis, and the measurement data are expressed by mean ± standard deviation (± s). The two samples were compared by t-test. Spearman was used to analyze the correlation between body composition and bone mineral density. The relationship between bone mineral density and body composition was analyzed by linear regression. The difference was statistically significant (P < 0.05).

3. Results

3.1. General Information. The screened 90 women were finally included in this study, age (54.84 ± 7.88) years, height (158.94 ± 5.30) cm, weight (65.37 ± 10.41) kg, and BMI (25.86 ± 3.87) kg/m². The waist hip ratio and body fat percentage of the study group were higher than the normal level, and the body composition was (see Table 1 for details).

3.2. Comparison of Bone Mineral Density with Different BMI. According to the BMI grouping standard formulated by WGOC, the population is divided into the normal weight group and overweight/obesity group. By comparing the bone mineral density of lumbar spines L1-4 between the two groups, it can be seen that the bone mineral density of the overweight/obesity group is significantly higher than that of the normal weight group (see Table 2 for details).

3.3. Correlation Analysis and Multiple Regression Analysis between Body Composition and Bone Mineral Density. Spearman correlation analysis showed that age was negatively correlated with L1-4 BMD, and skeletal muscle, upper limb muscle, trunk muscle, lower limb muscle, and whole-body phase angle were negatively correlated with L1-4 BMD (see Table 3 for details).

3.4. Multiple Regression Analysis of Body Composition and Bone Mineral Density. Skeletal muscle, including upper limb muscle, trunk muscle, and lower limb muscle, was used as independent variables for multiple linear regression analysis. L1-4 bone mineral density is the dependent variable and age, and skeletal muscle and whole-body phase angle are the independent variables. Multiple linear regression analysis shows that age is the negative influencing factor of bone mineral density, and skeletal muscle is the protective factor of BMD (see Table 4 for details).

Taking L1-4 BMD as dependent variable and age, and upper limb muscle, trunk muscle, lower limb muscle, and whole-body phase angle as independent variables, linear regression analysis shows that age is a negative influencing factor of BMD, and lower limb muscle is a protective factor of BMD (see Table 5 for details).

4. Discussion

The outcomes of body composition analysis mainly provide the proportion of water, muscle, fat, and inorganic salts in the total body mass. These values can be used to evaluate the nutritional and energy metabolism status and overall health status of the body and can guide the diagnosis, treatment, and prognosis of a variety of diseases [41]. The present study suggests that lower limb muscle mass is a
protective factor to keep the normal index of BMD in the female working in the city of Tai’an.

As early as the 1990s, the relationship between BMI, body weight, and bone health has been well studied, but the conclusions derived from different studies have not been consensual. Evans et al. illustrated that the areal BMD of the whole body, lumbar spine, hip, tibia, and radius of obese adults was higher than that with normal weight. Plus, the number of cortical bone and trabecular bone was significantly increased [17]. Yang and Shen also proved that the BMD of spine and femoral neck received a promotion accompanied with the increase of BMI and hip circumference [42]. However, Compston et al. reported an increased risk of ankle and femoral fractures in postmenopausal obese women [43]. The proportion of body compositions is

| Project                        | Minimum | Maximum | Mean (x) | Standard deviation |
|--------------------------------|---------|---------|----------|--------------------|
| Age (y)                        | 37      | 85      | 54.84    | 7.88               |
| Height (cm)                    | 146.1   | 171.3   | 158.94   | 5.3                |
| Weight (kg)                    | 46.5    | 101.8   | 65.37    | 10.41              |
| BMI(kg/m²)                     | 19.3    | 39.8    | 25.86    | 3.87               |
| Waist hip ratio                | 0.83    | 1.11    | 0.94     | 0.061              |
| Skeletal muscle mass (kg)      | 15.8    | 28.8    | 21.99    | 2.85               |
| Body fat (kg)                  | 13.2    | 51.9    | 24.68    | 7.4                |
| Percentage of body fat (%)     | 25.6    | 52.7    | 37.15    | 6.05               |
| Upper limb muscle mass (kg)    | 2.74    | 6.47    | 4.24     | 0.73               |
| Trunk muscle mass (kg)         | 14.1    | 25.2    | 18.92    | 2.25               |
| Lower limb muscle mass (kg)    | 8.37    | 15.97   | 12.34    | 1.77               |
| Upper limb fat (kg)            | 1.6     | 11.3    | 3.75     | 1.66               |
| Trunk fat (kg)                 | 6.1     | 25.6    | 12.6     | 3.81               |
| Lower limb fat (kg)            | 4       | 13.1    | 7.11     | 1.84               |
| Visceral fat area (cm²)        | 54.4    | 262.6   | 127.68   | 43.83              |
| Whole-body phase angle (°)     | 3.6     | 5.9     | 4.88     | 0.47               |
| Lumbar 1-4 bone mineral density (g/cm²) | 0.566 | 1.539 | 1.007 | 0.191          |

| Project                        | n       | Mean   | Standard deviation | t      | P       |
|--------------------------------|---------|--------|--------------------|--------|---------|
| Normal weight group            | 33      | 0.943  | 0.207              | -2.008 | <0.05   |
| Overweight group               | 37      | 1.039  | 0.195              |        |         |

| Project                        | r       | P       |
|--------------------------------|---------|---------|
| Age (y)                        | -0.43   | <0.01   |
| BMI (kg/m²)                    | 0.251   | <0.05   |
| Waist hip ratio                | -0.041  | >0.05   |
| Skeletal muscle mass (kg)      | 0.453   | <0.01   |
| Body fat (kg)                  | 0.152   | >0.05   |
| Percentage of body fat (%)     | 0.059   | >0.05   |
| Upper limb muscle mass (kg)    | 0.388   | <0.01   |
| Trunk muscle mass (kg)         | 0.373   | <0.01   |
| Lower limb muscle mass (kg)    | 0.419   | <0.01   |
| Upper limb fat (kg)            | 0.138   | >0.05   |
| Trunk fat (kg)                 | 0.144   | >0.05   |
| Lower limb fat (kg)            | 0.176   | >0.05   |
| Visceral fat area (cm²)        | 0.049   | >0.05   |
| Whole-body phase angle (°)     | 0.208   | <0.05   |

| Project                        | Standard β value | P value |
|--------------------------------|-----------------|---------|
| Age (y)                        | -0.355          | <0.01   |
| Skeletal muscle mass (kg)      | 0.35            | <0.01   |

| Project                        | r value | P value |
|--------------------------------|---------|---------|
| Age (y)                        | -0.333  | <0.01   |
| Lower limb muscle mass (kg)    | 0.618   | <0.01   |
Data Availability

No data were used to support this study.

Disclosure

The work described has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all coauthors, if any, as well as by the responsible authorities—tacitly or explicitly—at the institute where the work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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of Bone and Mineral Metabolism, vol. 34, no. 6, pp. 703–713, 2016.

[8] B. Guo, Q. Wu, J. Gong et al., “Gender difference in body fat for healthy Chinese children and adolescents,” Childhood Obesity, vol. 12, no. 2, pp. 144–156, 2016.

[9] W. D. Leslie, E. S. Orwoll, C. M. Nielsen et al., “Estimated lean mass and fat mass differentially affect femoral bone density and strength index but are not FRAX independent risk factors for fracture,” Journal of Bone and Mineral Research, vol. 29, no. 11, pp. 2511–2519, 2014.

[10] R. Rizzoli, H. Bischoff-Ferrari, B. Dawson-Hughes, and C. Weaver, “Nutrition and bone health in women after the menopause,” Women’s Health, vol. 10, no. 6, pp. 599–608, 2014.

[11] Y. Jiang, Y. Zhang, M. Jin, Z. Gu, Y. Pei, and P. Meng, “Aged-related changes in body composition and association between body composition with bone mass density by body mass index in Chinese Han men over 50-year-old,” PLoS One, vol. 10, no. 6, article e0130400, 2015.

[12] C. G. Gjesdal, J. L. Halse, G. E. Eide, J. G. Brun, and G. S. Tell, “Impact of lean mass and fat mass on bone mineral density: the Hordaland health study,” Maturitas, vol. 59, no. 2, pp. 191–200, 2008.

[13] L. Aguirre, N. Napoli, D. Waters, C. Qualls, D. T. Villareal, and R. Armamento-Villareal, “Increasing adiposity is associated with higher adipokine levels and lower bone mineral density in obese older adults,” The Journal of Clinical Endocrinology and Metabolism, vol. 99, no. 9, pp. 3290–3297, 2014.

[14] F. Ponti, A. Santoro, D. Mercattel et al., “Aging and imaging assessment of body composition: from fat to facts,” Frontiers in endocrinology, vol. 10, p. 861, 2020.

[15] W. J. Yu, Z. Zhang, W. Z. Fu, J. W. He, C. Wang, and Z. L. Zhang, “Association between LGR4 polymorphisms and peak bone mineral density and body composition,” Journal of Bone and Mineral Metabolism, vol. 38, no. 5, pp. 658–669, 2020.

[16] I. O. Bierhals, J. Dos Santos Vaz, R. M. Bilemann et al., “Associations between body mass index, body composition and bone density in young adults: findings from a southern Brazilian cohort,” BMC Musculoskeletal Disorders, vol. 20, no. 1, p. 322, 2019.

[17] A. L. Evans, M. A. Paggiosi, R. Eastell, and J. S. Walsh, “Bone density, microstructure and strength in obese and normal weight men and women in younger and older adulthood,” Journal of Bone and Mineral Research, vol. 30, no. 5, pp. 920–928, 2015.

[18] G. Gava, I. Mancini, I. Orsili et al., “Bone mineral density, body composition and metabolic profiles in adult women with complete androgen insensitivity syndrome and removed gonads using oral or transdermal estrogens,” European Journal of Endocrinology, vol. 181, no. 6, pp. 711–718, 2019.

[19] I. R. Reid, L. D. Plank, and M. C. Evans, “Fat mass is an important determinant of whole body bone density in premenopausal women but not in men,” The Journal of Clinical Endocrinology and Metabolism, vol. 75, no. 3, pp. 779–782, 1992.

[20] J. E. Compston, J. Fialhove, D. W. Hosmer et al., “Relationship of weight, height, and body mass index with fracture risk at different sites in postmenopausal women: the Global Longitudinal study of Osteoporosis in Women (GLOW),” Journal of Bone and Mineral Research, vol. 29, no. 2, pp. 487–493, 2014.

[21] O. Kapus, A. Gaba, and M. Lehnert, “Relationships between bone mineral density, body composition, and isokinetic strength in postmenopausal women,” Bone Reports, vol. 12, article 100255, 2020.

[22] K. R. Chrisostomo, T. L. Skare, H. R. Chrisostomo, E. J. L. Barbosa, and R. Nishihara, “Transwomen and bone mineral density: a cross-sectional study in Brazilian population,” The British Journal of Radiology, vol. 93, no. 1111, 2020.

[23] T. M. Link and G. Kazakia, “Update on imaging-based measurement of bone mineral density and quality,” Current Rheumatology Reports, vol. 22, no. 5, p. 13, 2020.

[24] D. T. Felson, Y. Zhang, M. T. Hannan, and J. J. Anderson, “Effects of weight and body mass index on bone mineral density in men and women - the Framingham study,” Journal of Bone and Mineral Research, vol. 8, no. 5, pp. 567–573, 1993.

[25] P. Dimitri, N. Bishop, J. S. Walsh, and R. Eastell, “Obesity is a risk factor for fracture in children but is protective against fracture risk in adults: a paradox,” Bone, vol. 50, no. 2, pp. 457–466, 2012.

[26] V. Mpalaris, P. Anagnostis, D. G. Goulis, and I. Iakovou, “Complex association between body weight and fracture risk in postmenopausal women,” Obesity Reviews, vol. 16, no. 3, pp. 225–233, 2015.

[27] L. B. Rokoff, S. L. Rrifas-Shiman, K. M. Switkowsky et al., “Body composition and bone mineral density in childhood,” Bone, vol. 121, pp. 9–15, 2019.

[28] A. Halper, B. Sanchez, J. S. Hodges et al., “Bone mineral density and body composition in children with congenital adrenal hyperplasia,” Clinical Endocrinology, vol. 88, no. 6, pp. 813–819, 2018.

[29] D. Fintini, S. Cianfarani, M. Cofini et al., “The bones of children with obesity,” Frontiers in Endocrinology, vol. 11, p. 200, 2020.

[30] M. K. McVey, A. A. Geraghty, E. C. O’Brien et al., “The impact of diet, body composition, and physical activity on child bone mineral density at five years of age-findings from the ROLO kids study,” European Journal of Pediatrics, vol. 179, no. 1, pp. 121–131, 2020.

[31] J. M. Nagata, J. L. Carlson, N. H. Golden et al., “Associations between exercise, bone mineral density, and body composition in adolescents with anorexia nervosa,” Eating and Weight Disorders, vol. 24, no. 5, pp. 939–945, 2019.

[32] A. L. Arteze, E. Simonavice, T. A. Madzima et al., “Body composition and bone mineral density in breast cancer survivors and non-cancer controls: A 12- to 15-month follow-up,” European Journal of Cancer Care, vol. 27, no. 2, article e12824, 2018.

[33] R. Costa de Miranda, N. Di Lorenzo, A. Andreoli et al., “Body composition and bone mineral density in Huntington’s disease,” Nutrition, vol. 59, pp. 145–149, 2019.

[34] D. A. Abshire, D. K. Moser, J. L. Clasey et al., “Body composition and bone mineral density in patients with heart failure,” Western Journal of Nursing Research, vol. 39, no. 4, pp. 582–599, 2017.

[35] T. A. Bosch, A. F. Carbuin, P. R. Stanforth, J. M. Oliver, K. A. Keller, and D. R. Dangel, “Body composition and bone mineral density of division 1 collegiate football players: a consortium of college athlete research study,” Journal of Strength and Conditioning Research, vol. 33, no. 5, pp. 1339–1346, 2019.

[36] K. A. Jackson, M. T. Sanchez-Santos, A. L. MacKinnon et al., “Bone density and body composition in newly licensed...
professional jockeys,” *Osteoporosis International*, vol. 28, no. 9, pp. 2675–2682, 2017.

[37] A. Spangenberg, N. Maghsoudi, D. Dulnoan et al., “Bone mineral density and body composition are associated with circulating angiogenic factors in post-menopausal women,” *Calcified Tissue International*, vol. 99, no. 6, pp. 608–615, 2016.

[38] G. A. Thomas, B. Cartmel, M. Harrigan et al., “The effect of exercise on body composition and bone mineral density in breast cancer survivors taking aromatase inhibitors,” *Obesity*, vol. 25, no. 2, pp. 346–351, 2017.

[39] X. Cheng, H. Yuan, J. Cheng et al., “Chinese expert consensus on the diagnosis of osteoporosis by imaging and bone mineral density,” *Quantitative Imaging in Medicine and Surgery*, vol. 10, no. 10, pp. 2066–2077, 2020.

[40] M. Marra, R. Sammarco, A. De Lorenzo et al., “Assessment of body composition in health and disease using bioelectrical impedance analysis (BIA) and dual energy X-ray absorptiometry (DXA): a critical overview,” *Contrast Media & Molecular Imaging*, vol. 2019, pp. 1–9, 2019.

[41] N. L. Vieira, J. D. S. Nascimento, C. Q. Do Nascimento, J. B. Neto, and A. C. O. Dos Santos, “Association between bone mineral density and nutritional status, body composition and bone metabolism in older adults,” *The Journal of Nutrition, Health & Aging*, vol. 25, no. 1, pp. 71–76, 2021.

[42] S. Yang and X. Shen, “Association and relative importance of multiple obesity measures with bone mineral density: the National Health and Nutrition Examination Survey 2005-2006,” *Archives of Osteoporosis*, vol. 10, no. 1, p. 14, 2015.

[43] J. E. Compston, N. B. Watts, R. Chapurlat et al., “Obesity is not protective against fracture in postmenopausal women: GLOW,” *The American Journal of Medicine*, vol. 124, no. 11, pp. 1043–1050, 2011.

[44] D. H. Kang, L. F. Guo, T. Guo et al., “Association of body composition with bone mineral density in northern Chinese men by different criteria for obesity,” *Journal of Endocrinological Investigation*, vol. 38, no. 3, pp. 323–331, 2015.

[45] D. Agostini, S. Zeppa Donati, F. Lucertini et al., “Muscle and bone health in postmenopausal women: role of protein and vitamin D supplementation combined with exercise training,” *Nutrients*, vol. 10, no. 8, p. 1103, 2018.

[46] F. Chen, Q. Su, Y. Tu et al., “Maximal muscle strength and body composition are associated with bone mineral density in chinese adult males,” *Medicine*, vol. 99, no. 6, article e19050, 2020.

[47] M. B. Saquetto, F. F. Pereira, R. S. Queiroz, C. M. da Silva, C. S. Conceicao, and M. Gomes Neto, “Effects of whole-body vibration on muscle strength, bone mineral content and density, and balance and body composition of children and adolescents with down syndrome: a systematic review,” *Osteoporosis International*, vol. 29, no. 3, pp. 527–533, 2018.

[48] M. Visser, D. J. Deeg, P. Lips, and A., “Low vitamin D and high parathyroid hormone levels as determinants of loss of muscle strength and muscle mass (sarcopenia): the longitudinal aging study Amsterdam,” *The Journal of Clinical Endocrinology and Metabolism*, vol. 88, no. 12, pp. 5766–5772, 2003.