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Correlation of Muscle Strength and Mass with Bone Mineral Density in Postmenopausal Women

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ABSTRACT

Introduction: Osteoporosis is a systemic disease of the bone, which entails an increased risk of fracture, with high impact on morbidity, mortality and costs in the health system. Several studies have shown a relationship between muscle mass and strength with bone mineral density. Our objective is to determine the correlation between these variables in postmenopausal women. **Materials and Methods:** For the correlation study, 100 postmenopausal women older than 50 years were selected randomly and a sociodemographic survey was conducted, and muscle strength was determined by manual grip strength, which was measured with a digital dynamometer. Bone mineral density measurements and muscle mass were obtained with densitometry. The correlation between strength, muscle mass, and bone mineral density was determined by a Spearman correlation. **Results:** The average age was 62.8 ± 7.48. Femur and column bone mineral density were significantly related to the muscle mass index, weight, and body mass index. The prevalence of fragility fracture was 17%. The bone mineral density of the femur was lower in patients with fragile fracture, and there was a negative and significant correlation between femur bone mineral density and skeletal muscle mass index. **Conclusion:** Bone health studies should include the study of muscle mass index and the skeletal muscle mass index. The improvement of the muscle mass index can influence femoral and vertebral bone mineral density with significant impact on fragility fractures. This is the first study of its kind conducted in Colombia and South America.

INTRODUCTION

Osteoporosis is a systemic disease of bone, characterized by a decreased bone mass, deterioration of bone tissue, and disruption of its architecture, compromising the bone strength and increasing the risk of fractures (1, 2). The main fractures in patients with osteoporosis are hip, vertebral, and wrist fractures. The importance of fractures associated with osteoporosis lies in the morbidity and mortality that they bring, the costs to the health system, risk of functional loss, reduced mobility, depression, cognitive commitment, and future fractures, making this entity an important problem of public health (3-6).

Physiologically, bone and muscle are intimately related. The set of osteoclasts and osteoblasts that act coordinately on the same bone surface constitute the basic multicellular unit (BMU), which is in charge of bone remodeling and allows repair against microtraumas. When the muscular mass is eutrophic, the mechanical stimulus on the bone stimulates the BMU when the stimulus of the muscle exceeds the threshold of minimum force that is required for the remodeling; the balance between the resorption and the bone formation is maintained, thus conserving the mass. When muscle strength falls below the threshold, as occurs in older adults, bone remodeling is activated with a predominance of resorption, and therefore, a decrease in bone mass (7, 8). In the aging process there is a concomitant decrease in bone and muscle mass. In contrast to bone, muscle mass reaches its maximum peak around 25 years of age. Then, until the age of 50 there is a slight reduction of 5% in the number of muscle fibers and then decreases by 1% each year (9-11). Muscle strength decreases by 1.5% between 50 and 60 years of age and 3% subsequently (12). Several studies conducted in North America, Europe, and Asia have evaluated the relationship between bone mineral density (BMD) and muscle strength, concluding a directly proportional relationship between muscle strength and BMD, muscle quality can be related to an adequate functional performance, and the improvement of muscle mass and strength could contribute to better bone health, especially in women (13, 14). However, there are no studies that correlate these two factors in Colombian or Latin American women.

The objective of this study was to evaluate the correlation between BMD, strength, and muscle mass in colombian postmenopausal women who attended a center of fourth level of national reference complexity. Finally, the results of this research are expected to provide useful information and contribute to the development of tools that help address

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the challenges of global aging.

MATERIALS AND METHODS

A study was carried out to evaluate the correlation between bone mineral density, mass, and muscle strength in female patients who attended a bone densitometry at the endocrinology service of a fourth complexity level hospital located in Cali, Colombia. Women older than 50 years were eligible, who, independent of the indication, came to perform this diagnostic aid in the period between April 8, 2017 and November 3, 2017. Patients with stage 4 and 5 chronic kidney disease, intake of steroids for three months or more, history of myopathy, transplant, cirrhosis (Child B and C), cancer, and immobility were excluded, given the influence that all these factors can have on bone density measurements, mass, and muscular strength. Since there are no studies that evaluate the relationship between these variables, a sample was taken from the convenience sampling of 100 patients, which gave the study a power of 80%.

Demographic variables, such as age, and socioeconomic stratum, considered as an approximation to the hierarchical demographic difference, are based on housing conditions and population aspects; strata 1, 2 and 3 correspond to low strata, which are subsidies beneficiaries; strata 5 and 6 are high strata users with greater economic resources, which must pay extra costs, stratum 4 is not a beneficiary of subsidies, nor must it pay extra costs. Civil status, origin, and educational level were evaluated; medical history of chronic obstructive pulmonary disease, chronic kidney disease, smoking, and alcoholism were inquired to assess the burden of comorbidity. The performance of exercise and intensity, classified according to the speech test categorized as mild, moderate, vigorous, vigorous exhausting, exhausting, severe, and severe exhausting were also inquired. History of fragility fracture, family history of hip fracture, premature menopause (that occurred before 45 years) were obtained; likewise, clinical examination variables, such as weight, height, body mass index (BMI), muscle strength; muscle mass index (measurement obtained from muscle mass (kg) / height2 (m), skeletal muscle mass index (appendiceal muscle mass kg / height2 (m); BMD in the spine, femur, T score in spine and femoral neck, the latter measures taken by densitometry (Lunar Prodigy Advance). The muscle strength was determined by the force of manual grip with digital dynamometer.

For the statistical analyses, the quantitative variables were reported as average or median, and measures of dispersion, standard deviation, and interquartile range according to the fulfillment of normality assumptions through the Kolmogorov-Smirnov test. The categorical variables were described in absolute value and percentage. The correlation between strength and muscle mass with bone mineral density was determined by a Spearman correlation. The present study was approved by the ethics committee for the institutional biomedical research.

RESULTS

Of a total of 1,852 patients who went to the Fundación Valle del Lilí Hospital to perform a bone densitometry in the period between April 8, 2017 and November 3, 2017, 100 women were selected for the study. They were 50 years of age or more and met the inclusion criteria, and had agreed to participate in the study. They signed the informed consent form and were selected by the convenience sampling method (Figure 1).

The demographic characteristics of the population are shown in Table 1. The average age was 62.8 years, 82% of them were between 50 and 70 years of age. The majority of the population came from the urban area and corresponded to the socioeconomic strata 4, 5, and 6. The percentage of comorbidity was low (Table 1). The prevalence of osteopenia, according to the T-score of the spine was 40% and according to the T-score of the right femoral neck was 32%, while the prevalence of osteoporosis was 28% and 20% according to the T-score of the spine and right femoral neck, respectively.

When determining the correlation of BMD of the spine and the femoral neck with the measured variables, a significant ($p<0.05$) and positive relationship was found with height, weight, BMI, and muscle mass index (MMI) (Figure 2); the relation was significant, but negative for the column and femur BMD with age, and between skeletal muscle mass index (SMMI) and femur BMD. Muscular strength had no correlation with BMD, and had a positive relationship with height. The low percentage of patients with comorbidities did not allow for the establishment of relationships with medical pathologies (Table 1). The frequency of fragility fractures in this group of patients was 17% (Table 2), and there was a significant relationship between this type of fractures and BMD of the right femur (Figure 3).

DISCUSSION

Muscle and bone play an important role as endocrine organs that complement each other; this is how decarboxylated osteocalcin is directly associated with muscle strength ($p <0.005$) (15) and different types of myokines are directly related to osteoclastic activity and the generation of osteogenic factors (16), in addition to the demonstration of their mechanical relationship and the impact of aging in this relationship (17). Nevertheless, there are no studies that include Latin American postmenopausal women, where these two essential elements of the musculoskeletal system correlate in the clinical setting, understanding that it is a vulnerable population to develop pathologies, such as sarcopenia, osteopenia, osteoporosis, and osteoporotic fractures along with all their clinical implications.

The prevalence of osteopenia and osteoporosis in our population was 40% and 28%, respectively; taking dual-energy X-ray absorptiometry (DEXA) data from the spine, when measurements were taken from the femoral neck, they corresponded to 32.1% and 20.6%. At a national level, there is a absence of direct statistics that allow these data to be compared; however, in a study conducted in Bogotá with 206 densitometries of postmenopausal women, it was found that the prevalence of osteopenia and osteoporosis was 50% and 22.3%, respectively; taking DEXA data from the spine, the measurements corresponded to 44.7% and

10.2% if BMD data were taken from the femur, being slightly higher than that recorded in our study (18).

Mechanical muscle loading has been described as an important factor for the maintenance of bone health (19). However, the correlation in our study between BMD of the femur and spine with muscle strength was not statistically significant, perhaps, because the force has a positive impact on the microarchitecture and bone mineral density depending on the area that is worked on or exposed to exercise. That is to say, the grip strength would only correlate with the bone mineral density of the distal radius, which was not measured in our study (20, 21). However, this hypothesis is refuted in Japanese population in which a correlation between these variables was obtained (22). The strength measurement should include population grip strength, flexion strength, and hip abduction, which according to the studies of Pasco in 2015 in 863 women from 26 to 97 years, for each standard deviation that increases the bending force of the hip, the total BMD of the hip was increased by 10.4% (p = 0.009) and in terms of the strength of abduction of the hip there was an increase of 22.8% in the BMD (p = 0.025) (23). In addition, we must take into account the normal value of grip strength in the elderly according to the population. In the Colombian literature, a cross-sectional study was published in 2012, where1878 elderly people were evaluated. They found that the grip strength in non-frail elderly was greater than 15 kg / f (24); taking this cut-off point into account, we could possibly have a positive relationship between the grip strength, the muscle mass index (MMI), the SMMI, and the BMD since our population would have a force above the national average.

The prehensile strength and height also have a positive correlation, as demonstrated in a cross-sectional study where a statistically significant relationship existed between grip strength and height in 38 institutionalized elderly woman (25). In our investigation, we found a positive and statistically significant correlation between height, spine and femur BMD and muscle strength. Having a short-statured population can corroborate these findings.

A striking finding in our study was a significant positive correction between MMI and BMD of the femur and the spine, these results are consistent with a meta-analysis published in 2014 that includes 15,260 women between 18 and 92 years where muscle mass has a positive relation with BMD of the femoral neck, with the data adjusted for age (26). However, there are studies that refute this hypothesis, like a population in China that includes 516 men and 652 older women and no relation between the muscle mass and risk of osteoporosis was found (p = 0.205) (27). There are no local studies that can compare our results.

The prevalence of fragility fracture was 17%. In this population, it was found that BMD of the femur was significantly lower than the patients who did not have a history of fracture (0.7 (0.67-0.83) vs 0.83 (0.72 - 0.92)). There was no statistically significant difference in the SMMI between these two groups of patients. In this ambit, in a Argentinian study conducted in 2016 with 112 women, it was found that 41.4% of the patients with fracture due to fragility had sarcopenia (28); in another study conducted in 2013, they measured the prevalence of sarcopenia due to SMMI in patients with vertebral fracture and found that 43.7% of these patients were sarcopenic (29). Similarly, in another study carried out in 2015, they found that 216 women with vertebral fracture had a higher prevalence of sarcopenia due to SMMI (30). On the other hand, a Finnish study of 590 postmenopausal women found that those with a low SMMI not only had an OR of 12.9 of having osteoporosis in comparison with non-sarcopenic women but also had an OR of 2.7 of having osteoporotic fractures (31). However, recently a prospective study conducted in The Netherlands, with more than 5,000 older adults (55% women) found that there was no relationship between sarcopenia and osteoporosis or osteoporotic fractures, a finding that correlates with what we found in our study (32). Although in our study the relationship between the SMMI and the presence of osteoporotic fractures was not statistically significant, it is striking that the negative relationship between BMD in the femoral neck and SMMI is significant, taking into account that in this population the femoral BMD was significantly associated with osteoporotic fractures.

We could not find a correlation between practicing physical exercise and its intensity with BMD. An European study selected 37 postmenopausal women who participated in a muscular resistance program 3 times per week with a duration of 60 minutes per session for 16 weeks under the supervision of a physiotherapist, and they observed an increase in BMD in the hip (6%; p = <0.05), and an increase of sclerostin (p <0.001) and osteocalcin (p = 0.04) (33, 34). Although these results are not comparable because we did not measure the time for which the patients had been exercising or the type of exercise they performed, their results are encouraging.

We concluded that a statistically significant correlation existed between MMI and BMD in the vertebral spine and femur in postmenopausal women; notably, among the patients with osteoporotic fracture, the femoral BMD was significantly lower. Likewise, weight and BMI were positively and significantly related to BMD, which indicates that in the process of maintaining the bone health in women, it is essential to maintain the weight, primarily composed of muscle mass. The height played a very important role in the values of BMD, MMI, SMMI, and muscle strength in Colombian women. These data suggest that in order to improve the bone health of postmenopausal women, therapy for the muscle and bone are crucial. In postmenopausal women's bone health studies, muscle mass should also be evaluated. This is the first study of its kind conducted in Colombia and South America. Studies are needed to evaluate the impact of the type, intensity, and duration of physical activity on BMD. Our study had limitations, first it was a cross-sectional study, and secondly, the patients were recruited by convenience sampling.

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AUTHOR CONTRIBUTIONS
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CONFLICT OF INTERESTS
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