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ASSOCIATION BETWEEN BODY MASS INDEX AND DENSITY BONE MINERAL: A CROSS-SECTIONAL STUDY

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Abstract: Objectives: To verify the association between body mass index (BMI) and bone mineral density (BMD) in an isolated population from a city in the interior of Rio Grande do Sul - Brazil. Methods: Cross-sectional study with patients who underwent densitometry through dual energy X-ray absorption (DEXA). Data were collected at a private diagnostic imaging clinic located in a city in the interior of the state of Rio Grande do Sul. BMI was calculated according to the World Health Organization (WHO). The BMD assessment was performed by DEXA and classified according to the WHO. The bone sites analyzed were the total lumbar spine and the hip (femoral neck and total femur). Statistical analysis was performed using prevalence ratios (PR) and their respective 95% confidence intervals for the factors under study. Results: data from 998 patients were collected and only female data were analyzed, totaling 975 patients, with a mean of 60.98 years. The eutrophic population has 1.63 times the prevalence of osteopenia compared to the obese (PR=1.63; 95% CI 1.17-2.26). Regarding Osteoporosis, in the eutrophic group, the PR was 1.89 times the PR of the obese (PR=1.89; 95% CI 1.33-2.70) and 2.39 in the Overweight group in relation to the category obese (PR=2.39; 95% CI 1.39-4.12). Conclusion: The obese population has a lower prevalence of osteopenia compared to eutrophic, as well as a lower prevalence of Osteoporosis compared to both eutrophic and overweight.
Keywords: Osteoporosis, osteopenia, Obesity, Overweight, body mass index.

INTRODUCTION

Obesity and Osteoporosis are two chronic diseases with high prevalence in society and in the modern world. They constitute a public health problem, mainly because they are asymptomatic conditions over the years and with later clinical repercussions, after years of evolution. They have a high probability of complications, such as a higher incidence of type 2 diabetes mellitus (type 2 DM), an increase in cardiovascular events and fractures. In the last 20 years, there has been a progressive increase in Obesity due to poor lifestyle habits seen mainly in the United States, where the prevalence rates reach approximately 35% in adults and 15% in children. Osteoporosis, on the other hand, does not spare ethnicity or location, consisting of numerous risk factors (BANDEIRA et al, 2007).

According to the World Health Organization (WHO), Obesity is characterized by excess body fat, in amounts capable of determining damage to the health of individuals. A person is considered obese when the body mass index (BMI) calculated by dividing weight (in kilograms) by height (in meters) squared is greater than or equal to 30 kg/m2, while the normal range varies from 18.5 to 24.9 kg/m 2. Individuals who are between the values in the range of 25 to 29.9 kg/m2 are considered overweight and may already have losses due to excess fat (BANDEIRA et al, 2007).

In univariate analyzes on prevalence and risk factors in Osteoporosis, it was observed that the disease was associated with older age, longer amenorrhea, lower BMI, white ethnicity and late menarche. Ethnicity is a well-defined risk factor, in which black women have a lower risk of Osteoporosis, unlike white and oriental women; as also demonstrated by an American study based on hospital discharge data, in which black women have a lower risk of hip fracture. Still, it asserts greater importance of reproductive and anthropometric variables on factors related to lifestyle (FAISAL-CURY et al, 2007).

The relationship between Osteoporosis and Obesity has been known and studied for years. Studies show that Obesity is seen as a protective

factor for Osteoporosis and its consequences, especially in relation to fractures. This is based on the positive correlation of bone mineral density (BMD) with BMI, demonstrating a lower incidence of hip fractures in obese individuals. However, there are studies that also contest this protective relationship of Obesity on Osteoporosis, in which they describe that obese individuals evaluated based on increased BMD in all regions do not have sufficiently high bone strength for all parts of the human body (SOUZA GOMES et al. al, 2019).

There are several determinants of BMD, which can be divided into non-modifiable risk factors and modifiable risk factors. Among the former, family history, advanced age, white race and chronic estrogen deficiency stand out. Regarding the modifiable ones, there are eating habits, lifestyle, smoking, prolonged use of corticosteroids, excessive coffee and alcohol intake, low body exposure and body composition (SOUZA GOMES et al, 2019). BMD is the main measurable risk predictor for fragility fractures, and studies confirm that, when associated with a lower BMI, the number of fractures increases considerably (MAZOCCO et al, 2017).

In this context, several mechanisms are proposed to elucidate the possible beneficial effect of Obesity on bone mass, reducing the incidence of Osteoporosis. Among them are the increase in the mechanical load on the skeleton (due to the adaptation of the skeleton to the increase in mechanical force induced by greater body weight) and metabolic factors, due to the greater production of estrogens due to the greater number of adipocytes, resulting in consequent reduced bone turnover. Furthermore, because of the relationship between Obesity and the hormones involved in appetite control. Leptin plays an important role in pubertal development and bone maturation, demonstrating positive effects on bone formation; although its central and peripheral effects may differ, because when administered directly into the brain ventricles of leptin-deficient mice, it is associated with potential bone loss (BANDEIRA et al, 2007).

Obesity has also been associated with insulin resistance, characterized by high plasma insulin levels and the development of type 2 DM. These high insulin levels can contribute to several abnormalities, which include the overproduction of androgens and estrogens in ovariyears in females and reduced production of sex hormone-binding globulins produced by the liver. These changes can occur in high levels of sex hormones, leading to an increase in bone mass due to the reduction of osteoclast activity and, then, possibly increasing the activity of osteoblasts, related to bone synthesis (BANDEIRA et al, 2007).

Adipocytes are important sources in the production of estrogen in postmenopausal women, a hormone known to inhibit bone resorption by osteoclasts. It is proposed that the increase in adipose tissue in this population, associated with an increase in BMI, results in an increase in estrogen production, osteoclast suppression and then an increase in bone mass (ZHAO et al, 2007).

Through research on Obesity, sarcopenia and bone mineral density in the elderly over 80 years, results reveal that in this age group, Obesity is a protective factor for osteopenia and Osteoporosis, both in the spine and in the femur and are based on the fact that mechanical loading stimulates bone formation, decreases apoptosis and increases osteoblast proliferation (SANTOS et al, 2018).

The proportion of fractures that occur in obese patients tends to increase with the increase in obesity in the world. Individuals with a higher BMI have a higher risk of fractures in some places, such as the ankle, leg and humerus, since the risk may be related to

the different pattern of falling when compared to non-obese patients. It is worth noting that the proportion of the obese population undergoing preventive treatment for fractures is low and the reasons need to be better explained through studies and elucidation of the scenario of involvement (PREMAOR et al, 2014).

Thus, this study aims to ratify this correlation in females, demystifying or proving the protective effect of Overweight and Obesity in the development of Osteoporosis. Thus, it corroborates the literature and facilitates the understanding of the prevalence of these indices in the population with Osteoporosis in the city of Santa Maria-RS, a city in the center of the state of Rio Grande do Sul, outlining a possible panorama of patients affected by the disease. Osteoporosis in Relation to Obesity and Enabling Future New Approaches.

METHODS

This is a cross-sectional, quantitative and qualitative study, carried out in a bone mineral densitometry database at the São Lucas Institute of Radiology, a private clinic in the city of Santa Maria - RS. All densitometry tests performed since the establishment of this service at the Instituto de Radiologia São Lucas in the city of Santa Maria - RS, covering the period from 2017 to 2020, are included in the research.

Data collection was carried out in a database system, after approval by the Ethics and Research Committee of the Franciscan University (UFN) and presentation of the Confidentiality Term and the Term of Authorization and Commitment for the Use of Data in Archive. The data, objects of this study, were collected from the DEXA exam bank, of the Instituto de Radiologia São Lucas, being inserted and organized in spreadsheets in the Excel platform and later analyzed under a quantitative and qualitative bias.

The present study will not, under any circumstances, reveal data that identify patients. Likewise, at no time will you contact a patient, as it is just an analysis of a database.

RESULTS

Through the analysis of the database obtained from BMD from the São Lucas Institute of Radiology in the city of Santa Maria - RS, from 2019 to 2020. A total of 998 patients, 975 women and 23 men (eliminated from the study for not make up a significant sample).

The descriptive statistics of the database thus comprised female patients, BMI, BMD results and variables such as age, weight and height, enabling better characterization of the sample. In this context, 63.38% of the sample was overweight or obese, as defined by the WHO. In addition, 36.62% had Normal weight, as shown in table 1.

Variables	n	%
Gender		
Female	975	100%
BMI		
Normal weight	357	36,62%
Overweight	376	38,56%
Obesity	242	24,82%
Bone Densitometry		
Normal exam	280	28,71%
Osteopenia	513	52,61%
Osteoporosis	182	18,66%

Table 1 – Descriptive statistics of the total sample.

Source: Author

When analyzing separately only the patients with Osteoporosis, which totaled 182, it appears that the eutrophic population has 1.89 times the prevalence of Osteoporosis compared to the obese (PR=1.89; 95% CI 1.33-2.70). In the group of overweight patients, the prevalence is 2.39 times that of

obese patients (PR=2.39; 95% CI 1.39-4.12) see table 2.

A similar pattern to that of patients with osteoporosis is observed in patients with osteopenia, who totaled 513, in which the eutrophic population has 1.63 times the prevalence of osteopenia compared to the obese (PR=1.63; 95% CI 1.17-2,26) according to data presented in table 3. Corroborating the results presented so far, it was observed that only 10.4% of obese patients have osteoporosis, while in eutrophic and overweight patients, 54.6% and 35%, respectively, of the population have osteoporosis, as shown in graph 1.

DISCUSSION

The present study observed in the results of BMD exams in the period of 2019 and 2020 that there is an influence of BMI on the prevalence of osteoporosis. This result, therefore, is in agreement with the data in the literature, which for the most part indicate

	Osteoporosis (%)	RP	*p*
Obesity	10,4%	1	
Eutrophy	54,6%	1,89 (1,33-2,70)	< 0,001
Overweight	35%	2,39 (1,39-4,12)	0,001
< 49 years	2,7%	1	
50-59 years	20%	3,18(1,22-8,29)	< 0,001
60-69 years	42,2%	6,86 (2,71-17,37)	< 0,001
≥ 70 years	35,1%	11,14 (4,35-28,56)	< 0,001

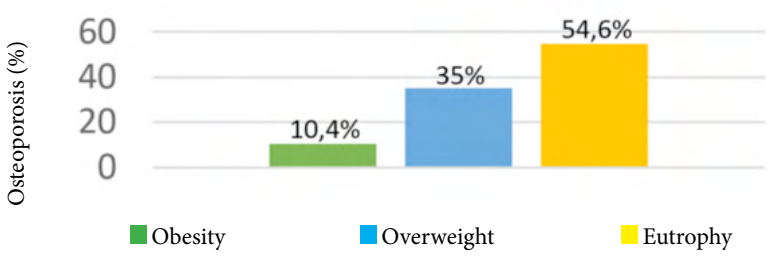
Table 2 - Osteoporosis Prevalence Ratio (PR) by BMI and age group.

Source: Author

	Osteopenia (%)	RP	p
Obesity	20,8%	1	
Eutrophy	39,3%	1,63 (1,17-2,26)	0,003
Overweight	39,9%	1,50 (1,08-2,08)	0,014
< 49 years	10,3%	1	
50-59 years	31,9%	1,47 (0,97-2,24)	0,068
60-69 years	36,6%	1,59 (1,05-2,39)	0,027
≥ 70 years	21,2%	1,55 (0,99-2,43)	0,054

Table 3 - Prevalence Ratio (PR) of osteopenia in the categories of BMI and age group.

Source: Author



Graph 1 - Presence of osteoporosis according to BMI category

Source: Author

that BMI is configured as a modifiable risk factor for osteoporosis, observing a protective factor of the increase in BMI in the prevalence of osteoporosis.

Comparatively, other studies present in the literature published the results of a retrospective study in which they evaluated 588 women between 41 and 60 years of age. In this study carried out exclusively in females, with a mean age of 54 years, those with a BMI above 40 kg/m2, chronic diseases such as renal, liver and heart failure, use of corticosteroids, smokers above 10 cigarettes per day and alcoholics (no reported amounts). BMD tests were performed using the DEXA system and a higher prevalence of osteoporosis was found in the lumbar spine and femoral neck in patients with normal weight when compared to those with obesity (BANDEIRA et al, 2007).

In another observational study carried out in Rio Grande do Sul, 393 postmenopausal women, with a mean age of 59.6 years, underwent BMD tests. It was concluded that eutrophic women had 1.2 times the prevalence of osteopenia and twice the prevalence of osteoporosis. Thus, it appears that obese women had a lower prevalence of osteopenia and osteoporosis compared to those with normal weight (MAZOCCO et al, 2017).

Some more recent studies have shown that the association of BMD and obesity may not reflect the protective factor of adiposity against osteoporosis. Tang and colleagues identified shared genomic regions for determining fat mass and BMD. In their studies with 4,126 Caucasian individuals, the most common genes identified were GDF8, TNFa, II6 and P0N1 (TANG et al, 2007).

In a study conducted among Chinese and Caucasian subjects, they assessed fat mass and BMD. The group consisted of 1,988 Chinese (42% menopausal female) and 4,489 Caucasian (45% female), with a positive correlation between BMI and BMD, as well as between lean mass and BMD. However, there were also inverse correlations between BMD and fat mass in kilograms and BMD and percentage of fat mass (ZHAO et al, 2007).

The relationship between body weight and osteoporosis is discussed and widely debated, although complete elucidation on the subject and unanimous conclusions regarding the modifiable risk factor for the disease are not obtained. Several explanations about the possible protective effect of obesity on bone debate, suggesting that a greater mechanical load on bones corresponds to an increase in bone mass in order to accommodate this load, protecting the bone from future fractures. Corroborating the defense, adipocytes also influence bone mass because they are important hormonal sources of estrogen, which indirectly acts on the activity of osteoblasts and osteoclasts, resulting in an increase in bone mass (MAZOCCO et al, 2017).

Considering that the present study observed a protective factor of obesity in relation to osteoporosis and osteopenia, it is worth noting that not all types of fat are related to a possible benefit on bone structure. According to the literature, visceral and subcutaneous fat have opposite effects on bone mass. While the former is related to systemic inflammation and increased levels of pro-inflammatory cytokines such as TNF and IL-6, which increase bone resorption and favor osteoporosis; subcutaneous fat appears to be favorable to the maintenance and formation of bone mass, as adiponectin (a potentially protective protein against osteoporosis) is present at higher levels of visceral versus subcutaneous fat (FONTANA et al, 2017; GILSANZ et al, 2019).

The correlation between osteopenia and obesity is also seen in other studies that aim to clarify the concomitant presence of these two factors. In a study carried out at the

Faculdade de Saúde Pública of the University of São Paulo (USP), 218 individuals over 50 years of age were analyzed in terms of these parameters based on DEXA BMD tests; in which 52% were female and with a mean age of 63 years. They concluded that only 23% of patients with osteopenia and/or reduced lean mass were obese (FRANÇA, 2019).

CONCLUSION

In the analysis of the sample of women who underwent BMD exams in the central region of the state of Rio Grande do Sul, a significant difference was observed in relation to the incidence of osteoporosis in eutrophic and dystrophic women (overweight and obesity). This way, body fat seems to exert a protective factor in relation to fractures and the consequences of osteoporosis and osteopenia, both by the mechanical effect and by adipocytes, since these are essential in the production of estrogens.

In summary, in this present study, the obese population had a lower prevalence of osteopenia and osteoporosis compared to the eutrophic population, as well as a lower prevalence of osteoporosis in relation to overweight people, evidencing that a higher BMI acts as a protective factor in the development of osteoporosis. and osteopenia. These results corroborate most of the literature on the subject.

The present study aims to contribute to further studies and elucidation of the real modifiable risk factors of the condition, in order to understand and interfere in the positive prognosis of the disease that affects a large number of patients, especially females. Under no circumstances is the intention to stimulate and/or encourage the increase or maintenance of the BMI above normal just for the protective factor of the same for osteoporosis, but rather to assist in the understanding of the pathophysiology of this disorder.

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