FRACTURE OF THE PROXIMAL THIRD OF THE FEMUR AND BMI IN ELDERLY WOMEN

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Abstract

Background: Increasing life expectancy has provided a demographic aging, which results in an increased prevalence of chronic diseases, as well as falls and bone fractures in older people. The relationship between Body Mass Index (BMI) and the prognosis of the fracture of the proximal third of the femur remains unclear. The aim of this study was to evaluate this possible association.

Methodology: The study group consisted of 40 women aged between 65 and 99 years old, hospitalized in Hospital São João' Orthopedic and Traumatology Department due to a fracture of the proximal third of the femur. The control group was composed of 36 institutionalized elderly women, aged between 65 and 94 years old, without any history of this type of fracture. We carried out anthropometric measurements, body composition assessment by bioelectrical impedance analysis, sociodemographic and clinical data collection and cognitive and functional assessment.

Results: The control group mean BMI was 28,3kg/m² (sd=6,0) and the study group mean BMI was 25.5kg/m² (sd=4,9), which is significantly lower (p=0,029). By analysing the ROC curve, we concluded that a BMI below 22,6kg/m² is predictor of fracture risk.

Conclusion: We found that in elderly women, a higher BMI protects them from the fracture of the proximal third of the femur, therefore we should not promote a weight loss corresponding to a BMI below 22,6kg/m², which is near the lower limit of the range proposed by Lipschitz, in 1994.

Keywords:
Aging; Falls; Fracture of the proximal third of the femur; BMI.

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Resumo

Introdução: O aumento da esperança média de vida proporcionou um envelhecimento demográfico, o que se traduz num aumento da prevalência de doenças crónicas, bem como de episódios como quedas e fraturas ósseas em idosos. A relação entre o Índice de Massa Corporal (IMC) e o prognóstico destes episódios permanece pouco esclarecida. Assim, o objetivo deste trabalho foi avaliar esta possível associação.

Metodologia: O grupo de estudo consistiu em 40 mulheres com idades compreendidas entre os 65 e os 99 anos, internadas no Serviço de Ortopedia e Traumatologia do Centro Hospitalar São João por fratura do terço proximal do fémur. O grupo de controlo foi constituído por 36 idosas institucionalizadas, na faixa etária dos 65 aos 94 anos, sem história prévia deste tipo de fratura. Foi realizada a avaliação antropométrica (peso e altura), avaliação da composição corporal por análise de bioimpedância, recolha de dados sociodemográficos e clínicos e avaliação do estado cognitivo e estado funcional.

Resultados: O IMC médio do grupo de controlo foi 28,3kg/m² (dp=6,0) e do grupo de estudo foi 25,5kg/m² (dp=4,9), significativamente inferior (p=0,029). Por análise da curva ROC observou-se que ter um IMC abaixo de 22,6kg/m² é preditor do risco de fratura.

Conclusão: Verificou-se que, em idosas, um IMC mais elevado é protetor de fratura do terço proximal do fémur, pelo que não será justificável promover uma perda de peso correspondente a um IMC abaixo de 22,6 kg/m², valor próximo do limite inferior do intervalo proposto por Lipschitz, em 1994.

Palavras-chave:
Envelhecimento; Quedas; Fratura do terço proximal do fémur; IMC.

INTRODUCTION

The increase in life expectancy has provided a demographic aging, so that World Health Organization (WHO) estimates that between 2015 and 2050 the proportion of the world's population over 60 years will nearly double from 12% to 22%[1,2].

Aging increases the prevalence of chronic diseases like obesity and osteoporosis which become relevant public health problems[2-7]. Moreover, all the components of the postural balance are negatively affected by aging, for instants the visual acuity and the depth perception[8]. The most common manifestations include disequilibrium, misalignments, instability and falls[9]. Falls are responsible for 90% of the hip fractures and are the sixth cause of death in women aged over 65 years[10,11]. Another important factor in occurrence of these episodes is the sarcopenia, very prevalent in this age group and it's defined through two criteria: the gradual and generalized loss of skeletal muscle mass and the loss of muscular function[12]. Hypoestrogenism also seems to interfere in postural balance and it's positively related to osteoporosis, which explains the increased frequency of falls and fractures in women in postmenopausal period[13-16].

It's estimated that 30% of the older people living in community suffer a fall and, at least, 40% of them lead to wounds[17-20]. The majority of the fractures (>95%) results from a fall or an osteoporotic fracture and it's associated with a high morbidity, incapacity and reduction in life quality[21]. Moreover, falls can result in the post-fall syndrome which includes loss of autonomy, development of confusion states and depression, with a severe restriction in daily tasks[21].

In the last years it's been reported that the obesity is directly related with the increase of bone mineral density (BMD), although remaining uncertain if this results in a higher bone resistance, protecting against fractures. On the other hand, some authors report that the inflammatory cytokines secreted by adipose tissue and the advanced glycation end products induced by hyperglycemia tend to reduce the BMD and increase the fracture risk[22-25].

Specifically, regarding to the fracture of the proximal third of the femur, it's known that it's one of the most common traumatic injuries among older people, with high morbidity and mortality[26], demanding intensive medical care and functional rehabilitation for long periods[27]. It's estimated that the incidence of this fracture will dramatically increase in the next 20 years, and this is more evident in people aged 85 years or more[28]. The fractures of the proximal third of the femur include the head, the neck, intertrochanteric region and subtrochanteric region[29]. This type of fractures in older people is caused, generally, for small and unintentional traumas, as the falls from their own height[30].

It's been reported that it's more likely to happen in people with lower Body Mass Index (BMI)[31], so that it's globally accepted that the BMI classification for older people should be different from the one of the general population, although not having consensus in scientific community. In 1994, a work carried out for *Lipschitz*[32], defined, for older people, underweight a BMI under 22kg/m², normal weight a BMI between 22 and 27kg/m² and overweight a BMI over 27kg/m². Later *Hajjar* and collaborators, defined underweight a BMI under 24kg/m², normal weight a BMI between 24 and 29kg/m² and overweight a BMI over 29kg/m²[33].

Overall, the aim of this study is to evaluate the relationship between BMI and the fracture of the proximal third of the femur in women aged 65 or over. We also intend to analyze other risk factors, such as sociodemographic and clinical data and cognitive and functional status.

The dramatic consequences of the bone fractures in the older people life quality and its high health costs, give meaning to this study, in order to draw some possible prevention strategies.

METHODS

We conducted a case-control study to evaluate, during 8 months, a sample divided into two groups.

The study group consisted of 40 women aged between 65 and 99 years old, hospitalized in Hospital São João' Orthopedic and Traumatology Department due to a fracture of the proximal third of the femur. Masculine gender, age under 65 years and the diagnosis of internment for another fracture type (diaphysis of femur and distal

extremity) were exclusion criteria. The control group was composed of 36 institutionalized elderly women, but without any history of this type of fracture in the last 5 years, belonging to Centro Social e Paroquial do Amial and Centro Social e Paroquial da Areosa, both in the Port. Masculine gender, age under 65 years and and/or the ones that had suffered this type of fracture in last the 5 years.

In both groups we carried out anthropometric measurements (weight and height), body composition assessment by bioelectrical impedance analysis (*Inbody S10*), sociodemographic and clinical data collection and cognitive and functional status assessment (Mini-Mental State Examination of *Folstein* and *Katz* Index of Independence in Activities of Daily Living, respectively, incorporated in "documento de avaliação geriátrica do Núcleo de Estudos de Geriatria da Sociedade Portuguesa de Medicina Interna")[34].

In the study group, we used a wheelchair weight scale. In the control group, we used a conventional scale - *Omron Body Monitorial Composition BF511*. Because of the fact that the study group consisted of people with huge physical limitations caused by the trauma, it was not possible to follow the same height measurement method. Regarding to the height, we measured in lying position or through the following predictive equation using the hand length: Predicted Height (cm): 80.400 + 5.122 x hand length (cm)—0.195 x age (years) + 6.383 x gender (gender: women 0, men 1)[35].

All statistical analysis was performed using the IMB SPSS Statistics 23.0.0.0 version for Windows. A significance level of 0.05 was considered.

RESULTS

In the study group we evaluated 40 women aged between 65 and 99 and the mean age was 83 years (sd=8.3). In the control group women aged between 65 and 94 years and the mean age was 80 years (sd=7.6). No statistical differences were found between them (p=0.133).

In general, for the Mini-Mental State Examination of *Folstein*, the results were similar in both groups (p=0.473). In the study group we only got the answers from 26 individuals because of their clinical condition. The punctuation ranged between 6 and 29 points, with a mean of 20.2 (sd=7.0). In the control group, 34 individuals answered and the punctuation ranged between 5 and 28 points, with a mean of 19.7 (dp=5.5). Regarding to the functional state questionnaire (*Katz* Index of Independence in Activities of Daily Living) the results were similar in both groups (p=0.130), specifically, in the study group the mean punctuation was 5.2 (dp=1.5) and in the control group it was 5.2 (dp=0.9).

In the study group, 45% of the fractures occurred in the femur neck and 50% in the trochanteric region (20% trochanteric, 20% intertrochanteric and 10% subtrochanteric). There wasn't any information about the type of 5% of the fractures.

In the study group the weight ranged between 39.4kg and 94.0kg and the height ranged between 1.45m and 1.76m. In the control group the weight ranged between 38.8kg and 113.0kg and the height ranged between 1.35m and 1.65m. It was found significant differences between the mean BMI and height, for instants, women of the study group were significantly higher and had a lower BMI (table 1).

Table 1 — Weight, height and BMI of the sample

| | Study group (N=40) | | Control group (N=36) | | |
	Mean	Standard deviation	Mean	Standard deviation	p
Weight (kg)	61.6	13.1	64.2	14.4	0.408
Height (m)	1.55	0.071	1.51	0.064	0.005
BMI (kg/m²)	25.5	4.9	28.3	6.0	0.029

Regarding to body composition assessment, we only performed it in 15 subjects of the study group and 26 of the control group, namely body fat percentage, skeletal muscle mass and bone mineral content (table 2). In these last two parameters, it was observed higher values in the study group with significant differences. The mean body fat percentage was higher in the control group, even though with no statistical differences (p=0.239).
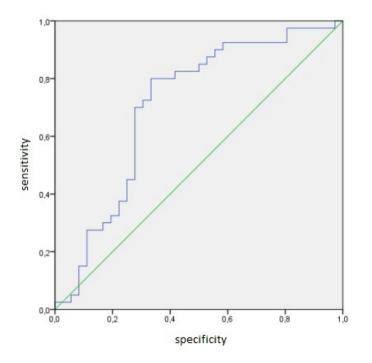
Table 2 — Body fat percentage, skeletal muscle mass and bone mineral content of the sample

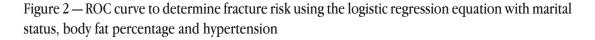|	Study group (N=15)		Control group (N=26)		
	Mean	Standard deviation	Mean	Standard deviation	p
Body fat percentage (%)	35.3	6.9	38.8	10.0	0.239
Skeletal muscle mass (kg)	22.5	4.2	19.9	3.4	0.040
Bone mineral content (kg)	2.51	0.41	2.21	0.35	0.015

The correlations between all the parameters were studied. We found a weak correlation between body fat percentage and bone mineral content (r=0.134, p=0.046) and a moderate correlation between skeletal muscle mass and bone mineral content (r=0.702, p<0.001), which suggests that it is more important the skeletal muscle than the body fat mass in determining bone mineral content.
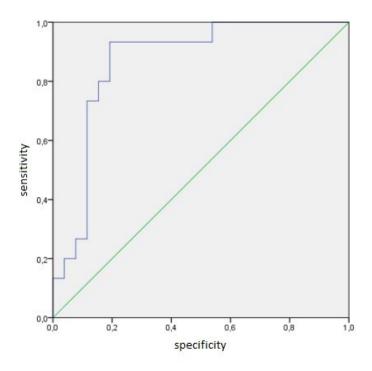
Besides the BMI, there are other factors associated to the fracture risk, so that we did a logistic regression to study the effect of the BMI, marital status, height, having hypertension, type 2 diabetes and dyslipidemia. In the last step, we observed that the fracture risk is lower in women with higher BMI, single or divorced, smaller and without hypertension. By analyzing the ROC curve using the logistic regression equation, we had an area under the curve of 0.706, so we got a cut-off point (with sensitivity 80% and specificity 66.7%) that corresponds to a BMI of 22.6kg/m² (figure 1). It means that a BMI below 22.6kg/m² seems to be predictor of fracture risk.

Figure 1 — ROC curve to determine fracture risk using the logistic regression equation with BMI, marital status, height and hypertension

Finally, we did a last logistic regression including marital status, height, body fat percentage, skeletal muscle mass, bone mineral content and having hypertension. In the last step it was verified that the results followed the same way of the others, which means that the fracture risk seems to be lower in single or divorced women, without hypertension, and with higher body fat percentage. By analyzing this ROC curve (area under the curve - 0.867), which was the best model, we obtained a cut-off point (with sensitivity 93.3% and specificity 80.8%) that corresponds to a body fat percentage of 36.4% (figure 2).

Figure 2 — ROC curve to determine fracture risk using the logistic regression equation with marital status, body fat percentage and hypertension

DISCUSSION

The current work emerged to give answers to one of the most controversial issues which is the relationship between the fracture of the proximal third of the femur and BMI in older women. Although being the most common type of fracture in older people[28], few studies have been carried out in this context, as well as the ones that exist have divergent outcomes.

Despite of the relevance of our findings, they should be interpreted within the context of limitations, namely the disparity of the anthropometric measurement methods in the study group due to their clinical condition. Besides, because of the lack of some body composition data, due to their reduced mobility and the limited resources of the hospital, these results should be interpreted with caution.

Regarding to the main approach of this work, we got a BMI cut-off point of $22.6 kg/m^2$. It means that a BMI below this value seems to be predictor of fracture risk and a BMI over that may be protective. These findings are in concordance with the work of *Lipschitz* in 1994, which established that a BMI below $22 kg/m^2$ is considered low weight in older people[32]. The results are also similar to the ones found by *Pagani R*. e collaborators[36], in which individuals who had a fracture of the proximal third of the femur had a lower mean BMI ($22.6 kg/m^2$; dp=3.9), in comparison with the control group ($25.5 kg/m^2$; sd=5.3).

The mean height was significantly higher in the study group. As the falls from their own height are the main cause of this type of fracture[30], it was expected that occurred more frequently in people with a higher center of mass. The body composition related outcomes seems to indicate a protective role of the adipose tissue, like has been reported for some authors[37,38]. It was obtained a body fat percentage cut-off point of 36.4%, so that

higher values may be protective. However, the BMI criterion is more viable in clinical context because it doesn't require specific equipment.

Overall, the outcomes of this work have strengthened the idea that the fracture of the proximal third of the femur is associated to lower BMI values, so that we should really use different cut-off points for older people in comparison to the ones established by WHO for the general population[39].

To sum up, the present study allowed to draw another possible strategy of prevention of this type of fractures in older people, through the maintenance of a BMI above 22.6kg/m². This is a way not only to prevent these episodes, but also to guarantee a better nutritional and general health state.

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