



## Original Article

# Body mass index as a prognostic factor for fracturing of the proximal extremity of the femur: a case–control study<sup>☆,☆☆</sup>



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## ABSTRACT

**Objectives:** To compare the body mass index (BMI) of patients with fractures in the proximal extremity of the femur with the BMI of patients without any previous history of fractures.

**Methods:** We investigated patients of both sexes, aged 65 years or over, who were admitted to Hospital Independência, Hospital Beneficência Portuguesa or ULBRA University Hospital, between December 2007 and December 2010, with histories of low-energy trauma such as falling from a standing position. These individuals were compared with patients of the same age but without any history of fracturing of the proximal extremity of the femur ( $n = 89$ ), who were attended at the geriatrics outpatient clinic of the Sociedade Porto-Alegrense de Auxílio aos Necessitados (SPAAN).

**Results:** The age group of the patients with fractures in the proximal extremity of the femur ranged from 65 to 96 years (mean: 77.58). The main type of fracture was trochanteric (47; 62.2%), followed by femoral neck fractures (27; 36%). Among the patients who presented on fracturing the proximal extremity of the femur, 12% had low weight, 62.7% normal weight, 24% overweight, and 1.3% obesity. Among the patients without any history of fractures, 5.6% presented low weight, 43.8% normal weight, 33.7% overweight, and 9.8% obesity. It was observed that the patients with fractures in the proximal extremity of the femur ( $n = 75$ ) presented a mean BMI of 22.6, while the patients without fractures presented a mean BMI of 25.5.

**Conclusion:** The patients in the group with fractures were significantly taller than those in the group without fractures and presented significantly lower BMI than those in the group without fractures.

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## Índice de massa corporal como fator prognóstico para fratura da extremidade proximal do fêmur: um estudo de caso-controle

### R E S U M O

#### Palavras-chave:

Fratura de quadril

Idoso

Índice de massa corporal

**Objetivos:** Comparar o índice de massa corporal (IMC) de pacientes com fratura da extremidade proximal do fêmur com o IMC de pacientes sem história prévia de fraturas.

**Métodos:** Investigamos pacientes de ambos os sexos, com 65 anos ou mais, internados no Hospital Independência, no Hospital Beneficência Portuguesa e no Hospital Universitário Ulbra, de dezembro de 2007 a dezembro de 2010, com história de trauma de baixa energia, como, por exemplo, quedas da própria altura, em relação aos pacientes da mesma idade e sem história prévia de fraturas da extremidade proximal do fêmur (n = 89) atendidos no serviço ambulatorial de geriatria da Sociedade Porto-Alegrense de Auxílio aos Necessitados (Spaan).

**Resultados:** A faixa etária dos pacientes com fratura da extremidade proximal do fêmur variou de 65 a 96 anos (média: 77,58). O principal tipo de fratura foi a trocantérica (47; 62,2%), seguida da do colo de fêmur (27; 36%). Entre os pacientes que apresentaram fratura da extremidade proximal do fêmur, 12% tinham baixo peso, 62,7%, peso normal, 24%, sobrepeso e 1,3%, obesidade. Entre os pacientes sem história de fratura, 5,6% apresentaram baixo peso, 43,8%, peso normal, 33,7%, sobrepeso e 9,8%, obesidade. Verificou-se que os pacientes com fraturas da extremidade proximal do fêmur (n = 75) apresentaram IMC médio de 22,6, enquanto os pacientes sem fraturas apresentaram IMC médio de 25,5.

**Conclusão:** Os pacientes do grupo com fratura são significativamente mais altos do que os do grupo sem fratura e apresentam IMC significativamente inferior ao do grupo sem fratura.

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## Introduction

Fractures of the proximal extremity of the femur are among the commonest traumatic injuries today, not only because of their high incidence in the elderly population but also because of the accompanying morbidity and mortality.

It has been estimated that the incidence of hip fractures will increase dramatically over the next 20 years. This increase will be most evident among individuals over the age of 85 years.<sup>1</sup> It has also been estimated that nine out of every 10 hip fractures occur in individuals over the age of 65 years.<sup>2</sup> The World Health Organization (WHO) has predicted that by the year 2050, the annual incidence will be 6.26 million.<sup>3</sup>

Fractures of the proximal extremity of the femur are a public health problem worldwide.<sup>4,5</sup> In addition to the high mortality rate, these patients require intensive medical care and functional rehabilitation over long periods.<sup>6</sup>

They are associated with considerable functional incapacity, diminished independence and quality of life and, especially, decreased life expectancy.<sup>7,8</sup>

Fractures of the proximal extremity of the femur comprise those of the head, neck, trochanteric region and subtrochanteric region.<sup>9</sup>

It is observed that these fractures in the elderly population are generally caused by small and unintentional traumatic events, such as falling from a standing position, which occur through the debility resulting from senescence and also depend on extrinsic factors.<sup>10</sup> A well-documented report has suggested that body mass index (BMI) is a significant prognostic factor for hip fractures.

In this context, fractures of the proximal femur may be associated with low BMI, which is considered to be a risk factor. Some authors have reported that the ideal BMI is 25–27.4 kg/m<sup>2</sup>. Lower indices than this are considered to be important prognostic factors for mortality among young and old hospitalized patients.<sup>11</sup>

It is suspected that obesity provides protection against fractures, but the mechanisms for such an association still remain poorly understood.<sup>12</sup>

Estrogen may protect against hip fractures in various manners, by increasing bone resistance, improving neuromuscular function, modifying fat deposition and improving the viscoelastic properties of the soft tissues.<sup>13</sup>

The possible hypotheses for the situation of greater risk of hip fracture among thin elderly people include: the role of adipose tissue in producing estrogen, which reduces the risk of hip fractures; greater weight increases the mechanical tension on bones and stimulates bone remodeling; and low weight may be an indicator or debilitated health, which in itself is a risk factor for falls and fractures.

Thus, the aim of the present study was to compare the BMI of patients of both sexes over the age of 65 years who were hospitalized between December 2007 and December 2010, with a diagnosis of fracture in the proximal extremity of the femur and a history of low-energy trauma (such as falling from a standing position), in relation to patients of the same age without any previous history of fracturing in the extremity of the proximal femur, who were attended at the geriatric outpatient service of Sociedade Porto-Alegrense de Auxílio aos Necessitados (SPAAN).

## Materials

This was a case-control scientific study in which 75 patients who were hospitalized between December 2007 and December 2010 due to fracturing the proximal extremity of the femur were assessed.

The patients were selected in accordance with the following criteria: age greater than or equal to 65 years; diagnosis for hospitalization relating to fracturing of the proximal extremity of the femur; and presence of a history of low-energy trauma such as falling from a standing position.

The criteria for excluding patients were: the presence of pathological fractures, distal fractures and fractures of the femoral diaphysis; situations of high-energy trauma; age under 65 years; presence of specific conditions that accentuate bone mass loss; and use of drugs that cause bone mass reduction.

## Methods

The patients studied were compared with a group of patients of the same age who did not have fractures of the proximal femur ( $n=89$ ) and who were attended at the geriatric outpatient service of SPAAN.

Data such as weight and height were ascertained from the medical files or were furnished by the patients, because of the difficulty of assessing these parameters among bedridden patients. Data such as age, sex, type of fracture (transtrochanteric, subtrochanteric or femoral neck) and fracture mechanism (falling) were recorded.

The BMI was calculated by dividing weight in kilograms by height in meters, squared. Four BMI categories were created: low weight ( $<18.5 \text{ kg/m}^2$ ); normal weight ( $18.5\text{--}25 \text{ kg/m}^2$ ); overweight ( $25\text{--}30 \text{ kg/m}^2$ ); and obese ( $>30 \text{ kg/m}^2$ ).

The data were analyzed by means of table, graphs and descriptive statistics. The following statistical tests were performed:

Chi-square test was used to ascertain whether there was any significant association among the qualitative variables between the study groups (with and without fractures), and, in relation to the group with fractures alone, to ascertain whether any association existed between the type of fracture and the other variables;

Student's *t* test was used to compare mean age, height, weight and BMI between the study groups (with and without fractures).

For all the abovementioned tests, the maximum significance level taken was 5% ( $p \leq 0.05$ ). The software used for the statistical analysis was SPSS version 10.0.

The data were stored in a specific database using the Microsoft Excel 2010 for Windows® software.

A search for articles relating to the study topic was conducted in electronic filing systems such as Pubmed, Lilacs and Scielo.

Proper authorization was obtained from the institutions for data gathering in their filing systems, and the project was approved by the ULBRA research ethics committee under protocol number 2010-237H.

## Results

In this section, the results relating to data gathered at the institutions investigated are presented and discussed (Table 1).

Through the results from the chi-square test, it was found that there were no significant associations in relation to the variables of age and sex between the groups (with and without fractures). In other words, there was no relationship between occurrences of fractures and these patients' sex and age. This test aims to ascertain whether any significant association exists between two qualitative variables. It is sought to find out whether any patient characteristic is more frequent in one given group than in another.

The age group of the patients with diagnoses of fractures of the proximal extremity of the femur ranged from 65 to 96 years, with a mean of 77.58.

In relation to sex among the patients with fractures, it was found that 56 (74.7%) were female and 19 (25.3%) were male (Fig. 1 and Table 2).

Through the results from the independent Student's *t* test, it was found in comparison between the above variables that the ones presenting a significant difference between the groups with and without fractures were the following:

- Height: it was observed that the patients in the group with fractures were significantly taller than those in the group without fractures;
- BMI: it was observed that the patients in the group with fractures presented significantly lower BMI than those in the group without fractures (Table 3).

The Student's *t* test aims at comparing values coming from two independent groups. It compares the values in each group (in this case, with and without fractures) with the aim of ascertaining whether there is any significant difference between these values.

Through the results from the chi-square test, it was found that there was a significant association between the variable of BMI classification and the group (with or without fracture). It was observed that normal weight was significantly associated with the group with fractures, while patients who were overweight or obese were associated with the group without fractures.

Among the patients who presented fractures of the proximal extremity of the femur, 12% presented low weight, 62.7% normal weight, 24% overweight, and 1.3% obesity. Among the patients without any history of fractures of the proximal extremity of the femur, 5.6% presented low weight, 43.8% normal weight, 33.7% overweight, and 9.8% obesity. It was found that the patients with fractures of the proximal extremity of the femur ( $n=75$ ) presented mean BMI of 22.6, while the patients without fractures presented mean BMI of 25.5 (Fig. 2 and Table 4).

Through the results from the chi-square test, it was found that there was a significant association between the variable of patient's age and the type of fracture. It was observed that patients up to the age of 70 years presented an association with femoral neck fractures, while those aged over 80 years presented an association with trochanteric fractures.

**Table 1 – Description of the sample investigated according to the variables of age and sex for the groups with fractures (n = 75) and without fractures (n = 89).**

Variable	Category	Group (%)		Total	p <sup>a</sup>
		With fractures	Without fractures		
Sex	Female	74.7	62.9	68.3	0.107
	Male	25.3	37.1	31.7	
Age	Up to 70 years	17.3	14.6	15.9	0.864
	From 71 to 80 years	45.3	44.9	45.1	
	Over 80 years	37.3	40.4	39.0	

Source: data gathered in 2011.

<sup>a</sup> p value (significance level). For associations to be considered significant, the p value needed to be a maximum of 5% ( $p \leq 0.05$ ).

**Table 2 – Comparison of the means for the quantitative variables of age, height and weight between the study groups.**

Variable	Group	n	Mean	Standard deviation	p
Age	With fractures	75	77.6	7.6	0.491 (NS)
	Without fractures	89	78.4	7.3	
Height	With fractures	75	1.62	0.11	0.000 <sup>a</sup>
	Without fractures	89	1.54	0.09	
Weight	With fractures	75	59.7	13.2	0.784 (NS)
	Without fractures	89	60.3	13.5	
BMI	With fractures	75	22.6	3.9	0.000 <sup>a</sup>
	Without fractures	89	25.5	5.3	

Source: data gathered in 2011.

NS, not significant.

<sup>a</sup> Significant at the significance level of  $p \leq 0.0001$ .

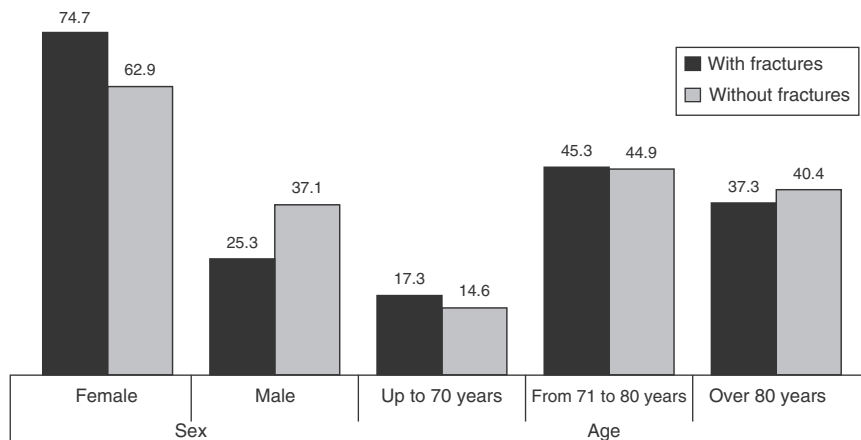
The main types of fracture presented in this study were trochanteric (47 cases; 62.2%), femoral neck (27; 36%) and subtrochanteric (1; 1.8%) (Fig. 3).

## Discussion

A total of 164 medical files were selected: 75 relating to patients aged 65 years and over with a diagnosis of fracture

in the proximal extremity of the femur; and 89 relating to patients without a previous history of fractures of the proximal extremity of the femur.

The ages of the patients with a diagnosis of fracture in the proximal extremity of the femur ranged from 65 to 96 years, with a mean of 77.58. The fracture cases were predominantly in the age range from 71 to 80 years (45.3%). Vilas Bôas Junior et al.<sup>14</sup> reported that the age range from 60 to 69 years was the one most affected (36.64%). Rocha et al.<sup>15</sup> found that the

**Fig. 1 – Description of the sample investigated according to the variables of age and sex for the groups with fractures (n = 75 cases) and without fractures (n = 89 cases).**

Source: data gathered in 2011.

**Table 3 – Description of the sample investigated according to the variable of BMI classification for the groups with fractures (n = 75) and without fractures (n = 89).**

BMI classification	Group (%)		Total	p
	With fractures	Without fractures		
Low weight	12.0	5.6	8.5	0.003 <sup>a</sup>
Normal weight	62.7	43.8	52.4	
Overweight	24.0	33.7	29.3	
Obese	1.3	16.9	9.8	

Source: data gathered in 2011.

<sup>a</sup> Significant at the significance level of  $p \leq 0.01$ . To perform the test on the BMI variable, the categories of overweight and obesity were grouped.**Table 4 – Comparison of sex, BMI and age in relation to the types of fracture that occurred, for the group with fractures alone (n = 75).**

Variable	Category	Type of fracture			p
		Femoral neck	Subtrochanteric	Trochanteric	
Sex	Female	70.4	100.0	76.6	0.693(NS)
	Male	29.6		23.4	
Age	Up to 70 years	33.3		8.5	0.010 <sup>a</sup>
	From 71 to 80 years	48.1		44.7	
	Over 80 years	18.5	100.0	46.8	
BMI classification <sup>b</sup>	Low weight	14.8		10.6	0.256(NS)
	Normal weight	70.4		59.6	
	Overweight/obese	14.8	100.0	29.8	

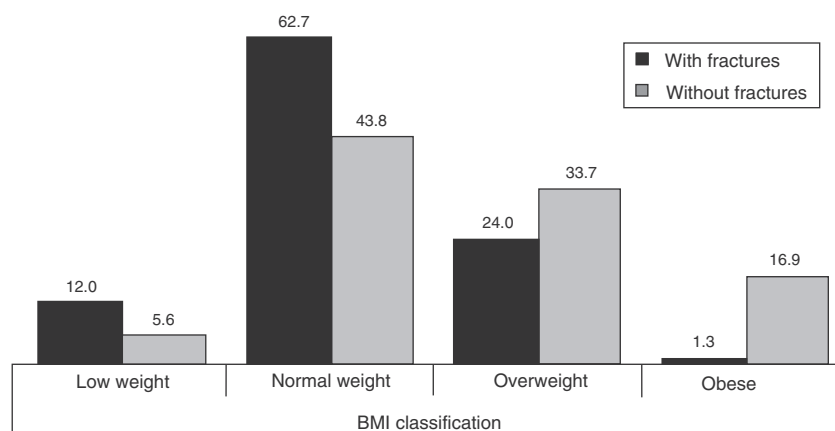
Source: data gathered in 2011.

NS, not significant.

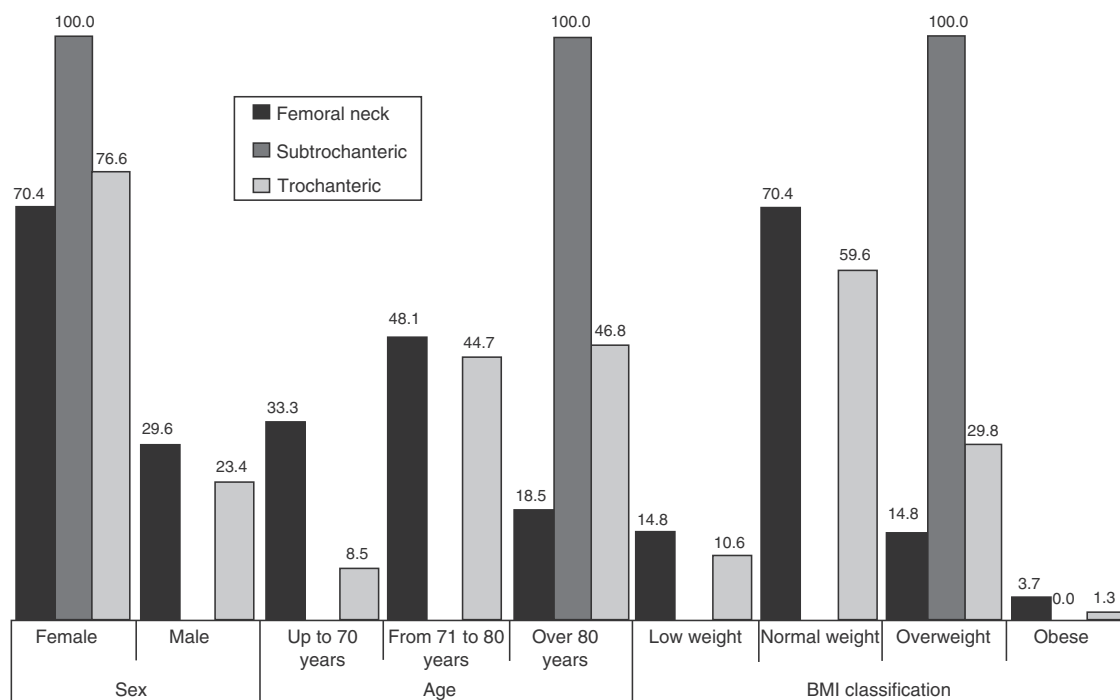
<sup>a</sup> Significant at the significance level of  $p \leq 0.01$ .<sup>b</sup> To perform the test on the BMI variable, the categories of overweight and obesity were grouped.

greatest incidence of fractures among their elderly patients was in the age range from 71 to 80 years (27.99%). Benetos et al.<sup>13</sup> observed that around 80% of the hip fractures occurred in women over the age of 70 years. Among the men, 50% were over the age of 70 years. The mean age at which hip fractures occurred was 81 years among women and 78 years among men.

In relation to sex, we found that 56 (74.7%) were female and 19 (25.3%) were male. According to Eisler et al.,<sup>16</sup> in a sample of 571 patients with proximal fractures of the femur, the observed incidence was 86% among females and 14% among males. Pereira et al.<sup>17</sup> also found that femoral fractures were predominantly among women. Espino et al.<sup>18</sup> reported that the incidence of fractures in women was 66% and that it was

**Fig. 2 – Description of the sample investigated according to the variable of BMI classification for the groups with fractures (n = 75 cases) and without fractures (n = 89 cases).**

Source: data gathered in 2011.



**Fig. 3 – Comparison of sex, BMI and age in relation to the types of fracture that occurred, for the group with fractures alone (n = 75 cases).**

**Source: Data gathered in 2011.**

34% in men. Aharonoff et al.<sup>19</sup> found that the incidence among women was 78.6%. Ramalho et al.<sup>20</sup> noted that femoral fractures occurred predominantly among women. Benetos et al.<sup>13</sup> found that the incidence of hip fractures was twice as high among women than among men.

The main types of fracture presented in this study were trochanteric fractures, with 47 cases (62.2%), femoral neck fractures, with 27 cases (36%) and subtrochanteric fractures, with one case (1.8%). In the literature, trochanteric fractures are presented as the most frequent type. Cunha and Veado<sup>21</sup> analyzed 190 patients (142 women and 48 men; mean age of 79 years) in the state of Minas Gerais who were hospitalized with fractures in the proximal extremity of the femur in the orthopedic ward of the State Public Servants' Hospital, among whom the incidence of trochanteric fractures was 50%, femoral neck fractures 44% and subtrochanteric fractures 6%.

IN relation to BMI, the patients were divided into four categories: low weight (<18.5 kg/m<sup>2</sup>), normal weight (18.5–25 kg/m<sup>2</sup>), overweight (25–30 kg/m<sup>2</sup>) and obese (>30 kg/m<sup>2</sup>). Among the patients with proximal fractures of the femur, 12% presented low weight, 62.7% normal weight, 24% overweight, and 1.3% obesity. Among the patients without any history of proximal fractures of the femur, 5.6% presented low weight, 43.8% normal weight, 33.7% overweight, and 9.8% obesity. It was found that the patients with fractures of the proximal extremity of the femur (n = 75) presented mean BMI of 22.6, while the patients without fractures (n = 89) presented mean BMI of 25.5.

A study conducted by Alfaro-Acha et al.<sup>1</sup> also confirmed that there was an inverse relationship between body weight and the risk of fracturing of the proximal extremity of the

femur and reported that a 10% weight loss significantly increased the risk of hip fractures among individuals aged 65 years and over. De Laet et al.<sup>22</sup> found a small difference in the risk of fractures among their patients, in relation to an increase in BMI of five units, from 25 kg/m<sup>2</sup> to 30 kg/m<sup>2</sup>, the difference observed was a 17% decrease in the risk of hip fractures. In relation to an increase in BMI of ten units, the difference observed was a 25% decrease in the risk of hip fractures. At the lower extremity of the BMI spectrum, a change of five BMI units from 25 kg/m<sup>2</sup> to 20 kg/m<sup>2</sup> corresponded to doubling the risk of hip fractures. Folsom et al.<sup>23</sup> confirmed that there was an inverse relationship between BMI and occurrences of hip fractures. Young et al.<sup>24</sup> reported that low BMI was a risk factor for hip fractures, while high BMI was a protective factor. Margolis et al.<sup>25</sup> found an association between low BMI or body size and increased risk of hip fractures. White et al.<sup>26</sup> only demonstrated a benefit from increased BMI among women, while there was no change in risk among men. Holmberg et al.<sup>27</sup> reported that increased BMI was protective against hip fractures in both men and women.

## Conclusion

The patients in the group with fractures were significantly taller than those in the group without fractures. In relation to BMI, the patients in the group with fractures presented significantly lower BMI than those in the group without fractures.

In view of the growing numbers of elderly people over recent years and the consequent increased frequency of hospital admissions due to fractures of the proximal extremity of

the femur, which directly influence elderly people's quality of life and independence, early detection of risk factors is needed in order to select treatments better, diminish the morbidity and mortality rates and reduce costs. These fractures have a direct bearing on society's economic situation, given that they lead to billions of dollars of expenditure on medical care.

### Conflicts of interest

The authors declare no conflicts of interest.

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