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Body mass index found not to be associated with metabolic indicators in patients with orthopedic trauma

Se encontró que el índice de masa corporal no se asocia con indicadores metabólicos en pacientes con traumatismo ortopédico

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ABSTRACT

Introduction: The relevance of the nutritional status in patients with orthopedic trauma (OT) has been enhanced in the literature.

Objective: This study compared overweight and obese patients with normal body weight patients and their relationship with nutritional and metabolic indicators.

Methods: Patients with OT (n=108) were investigated in a prospective study for body mass index (BMI) in relation to their calf circumference (CC), vitamin D and albumin serum levels.

The statistical analysis included the Chi-square or Fisher tests and the Mann-Whitney test and Spearman's linear correlation coefficient.

Results: There was no association between gender, type of fractured bone, laterality, smoking, diabetes, menopause, albumin and vitamin D and the two groups of patients classified by BMI. There was an association ($p < 0.0001$) only with CC, with lower CC values in patients with normal body weight.

Conclusion: BMI was not associated with metabolic indicators in patients with OT.

KEY WORDS

Orthopedic trauma, body weight, body mass index, vitamin D and albumin.

RESUMEN

Introducción: La relevancia del estado nutricional en pacientes con traumatismo ortopédico (TO) se ha reforzado en la literatura.

Objetivo: Este estudio comparó pacientes con sobrepeso y obesidad con pacientes con peso corporal normal y su relación con indicadores nutricionales y metabólicos.

Métodos: Los pacientes con TO (n = 108) fueron investigados en un estudio prospectivo para el índice de masa corporal (IMC) en relación con su circunferencia de la pantorrilla (CC), vitamina D y niveles séricos de albúmina. El análisis estadístico incluyó las pruebas de Chi-cuadrado o Fisher y la prueba de Mann-Whitney y el coeficiente de correlación lineal de Spearman.

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Resultados: No hubo asociación entre sexo, tipo de fractura ósea, lateralidad, tabaquismo, diabetes, menopausia, albúmina y vitamina D y los dos grupos de pacientes clasificados por IMC. Hubo asociación (p <0,0001) solo con CC, con valores de CC más bajos en pacientes con peso corporal normal.

Conclusión: El IMC no se asoció con indicadores metabólicos en pacientes con TO.

PALABRAS CLAVE

Trauma ortopédico, peso corporal, índice de masa corporal, vitamina D y albúmina.

INTRODUCTION

Nutritional status, obesity, malnutrition, hypovitaminosis, cardiovascular diseases and diabetes, osteoporosis, among others, have been recognized as risk factors for increased incidence of orthopedic trauma (OT)[1]. In addition, in the investigation of the study population nutritional status, the prevalence of reduced vitamin D serum levels in fractured patients was observed[8]. A cross-sectional study involving patients with fractures showed that increased sun exposure, alcohol consumption and the use of vitamin D were considered to be independent protective factors against severe vitamin D deficiency[5]. In the same study, it was also observed in a univariate analysis that male gender, older age, body mass index (BMI) ≥30, among others, were potential risk factors for vitamin D deficiency[5]. Other studies also point out that the risk of certain fractures is higher in obese people and that a significant number of fractures can occur in those subjects[23].

An investigation conducted in China[11] revealed an average age of 45.4 years at the time of the fracture. Fracture history, average sleep time (less than 7 hours a day) and alcohol consumption were identified as independent risk factors for foot fractures in men and women. In the study in question, BMI> 24 kg/m^2 in women was also detected as being a risk factor[11]. In view of these considerations, the use of BMI could contribute to a better monitoring in the care of patients with orthopedic trauma.

Thus, this study aimed to compare overweight and obese patients with normal body weight patients, and their relationship with nutritional and metabolic indicators.

METHOD

A prospective study was carried out in an orthopedics outpatient clinic of a hospital attending adult patients with foot and ankle fractures (n=108). The investigation was approved by the Institution's Ethics and Research Committee after the patients signed a free and informed consent form (FICF). According to the study design, adults of both genders with a previous fracture diagnosis of certain bones of the foot and/or ankle were included. Patients who did not accept to participate in the study, who were under the age of 18 years and those who were undergoing vitamin D replacement therapy, were excluded from the study. At the beginning of this investigation, a clinical anamnesis and an orthopedic physical examination were performed, with confirmation of foot or ankle fractures by simple radiography performed in the study hospital. Laboratory and nutritional status assessments were performed after fractures were confirmed and before the treatment was started. Demographic data, comorbidities, type of fractured bone, anthropometric indicators and laboratory tests were investigated.

The anthropometric indicators evaluated were body weight, height, body mass index (BMI) and calf circumference (CC). The BMI for individuals up to 65 years of age, was set according the World Health Organization criteria[25] and for individuals over 65 years of age, according to the Pan American Health Organization criteria[16]. Both Organizations classify patients as underweight, normal weight, overweight and obese[16,25]. The European Sarcopenia Consensus criteria[2] were considered for the classification of CC *(<34 cm for men and <33 for women).*

Biochemical tests for serum albumin and vitamin D were performed. Albumin levels were classified as[17]:- severe depletion: <2.4mg/dl; moderate depletion: 2.4 - 2.9mg/dl; mild depletion: 3.0 - 3.5mg/dl and normal:> 3.5mg/dl.

Vitamin D was classified and analyzed according to two classifications (2014 and 2018) of the *Sociedade Brasileira de Endocrinologia* (SBE, Brazilian Society of Endocrinology). According to the 2014 SBE classification[7,12,15], the vitamin D serum dosage was considered as:- normal (≥30 ng/dL), insufficient (20-29 ng/dL) and deficient (<20 ng/dL). According to the 2018 SBE[3], the vitamin D serum dosage was considered as:- normal for a healthy population up to 60 years of age (> 20 ng/dL), normal for risk groups and individuals over 60 years of age (≥30 ng/dL) and deficient (<20 ng/dl). For analysis purpose, the two vitamin D classifications and their relationship with the BMI were considered in this study.

Subsequently, for the analysis and comparison of the variables assessed, the patients were divided into two groups, according to the BMI classification: overweight plus obese patients (*BMI above the reference line*) and patients with normal body weight (*BMI below the reference line*).

In the statistical analysis, comparing proportions, the Chi-square test or Fisher's exact test were used when necessary, and the Mann-Whitney test was used to compare continuous measurements between the two groups. Spearman's linear correlation coefficient was used to investigate the relationship between BMI and the study variables of interest. The correlation coefficient can vary from -1 *(indicating a strong negative correlation between the two variables)* to 1 *(indicating a strong positive correlation between the two variables)*. Values close to zero did not indicate a linear correlation between the

two variables. The level of significance adopted for the statistical tests was 5%.

RESULTS

The studied population was composed of 108 patients, comprising 30.6% (n=33) men and 69.4% (n=75) women; mean age was 50.5 ± 15.9 years. According to the BMI classification, 67.59% (n=73) were overweight and obese and 32.40% (n=35) had normal body weight.

Table 1 shows the characteristics of the population and the comparison of the variables studied between the two groups of patients classified according to the BMI *(overweight plus obesity and with normal body weight)*. There was no significant difference between the variables *(gender, type of fractured bone, laterality, smoking, diabetes, menopause)* and the two groups of patients.

When comparing the variables between the two groups of patients classified according to the BMI (Table 2), a significant association (p<0.0001) was found only with CC, with lower mean values (32.8 ± 1.8 cm) and median values (33.0 cm) of CC in patients with normal body weight. Table 3 also shows a significant association between BMI and CC.

Table 1. Characteristics of the studied population and comparison between the two groups of patients (overweight plus obesity and with normal body weight) (n=108)

Variables	Overweight plus obesity* (n=73)		Normal body weight* (n=35)		Total (n=108)		P-value
	n	%	n	%	n	%	
Gender							
Female	51	69.9	24	68.6	75	69.4	0.8915[2]
Male	22	30.1	11	31.4	33	30.6	
Fractured Bone							
Foot	34	46.6	18	51.4	52	48.1	0.6366[2]
Ankle	39	53.4	17	48.6	56	51.9	
Side							
Bilateral	2	2.7	0	0.0	2	1.9	0.6143[2]
Right	41	56.2	22	62.9	63	58.3	
Left	30	41.1	13	37.1	43	39.8	
Smoking							
No	67	91.8	32	91.4	99	91.7	1.0000[3]
Yes	6	8.2	3	8.6	9	8.3	
Diabetic							
No	60	82.2	32	91.4	92	85.2	0.2060[2]
Yes	13	17.8	3	8.6	16	14.8	
Menopause							
No	23	45.1	9	37.5	32	42.7	0.5349[2]
Yes	28	54.9	15	62.5	43	57.3	

* Weight classification by body mass index.
[2] Chi-square test; [3] Fisher's exact test.

Table 2. Comparison between the variables studied and the two groups of patients (overweight plus obesity and with normal body weight) (n=108)

Variables		Overweight plus obesity* (n=73)	Normal body weight* (n=35)	Total (n=108)	P-value
Age (years)	X±SD	50.4 ± 14.2	50.9 ± 19.4	50.5 ± 15.9	0.8464[1]
	median	53.0	48.0	52.5	
CC (cm)	X± SD	35.5 ± 2.5	32.8 ± 1.8	34.6 ± 2.6	<0.0001[1]
	median	35.0	33.0	34.0	
Vitamin D (ng/dl)	X± SD	25.8 ± 8.4	26.9 ± 9.1	26.2 ± 8.6	0.4151[1]
	median	26.0	27.0	27.0	
Albumin (mg/dl)	X± SD	4.2 ± 0.4	4.3 ± 0.4	4.2 ± 0.4	0.6381[1]
	median	4.2	4.3	4.2	

* Weight classification by body mass index.
[1] Mann-Whitney Test; CC: Calf Circumference.

Table 3. Association between body mass index and calf circumference

Variables (%)	Overweight plus obesity* (n=73)		Normal body weight* (n=35)		Total (n=108)		P-value
	n	%	n	%	n	%	
Calf Circumference							
Reduction of muscle mass	7	9.6	17	48.6	24	22.2	<.0001[2]
No reduction	66	90.4	18	51.4	84	77.8	

* Weight classification by body mass index.
[2] Chi-Square Test.

There was no significant association between BMI and vitamin D and albumin found in the laboratory exams (Table 4).

The correlation data analyzed in this study showed that there was a significant correlation only between BMI and CC. There was no linear correlation between BMI and vitamin D, albumin and age (Table 5).

DISCUSSION

Factors such as nutritional status and BMI have been associated with a predisposition to fractures, as well as other clinical situations such as cardiovascular diseases and diabetes, obesity, malnutrition, osteoporosis and hypovitaminosis[1].

In the present investigation, in the assessment of nutritional and metabolic indicators and their relationship with body weight in patients with foot and ankle fractures, no association between body weight, gender, age, vitamin D, albumin and other variables assessed was found among the two groups of patients classified according to the BMI criteria *(overweight plus obesity and normal body weight)*. Only the CC was associated with BMI, and patients with normal body weight exhibited smaller CC values compared to the values of overweight and obese patients. Findings different from this investigation were observed in a retrospective study that investigated an association between obesity and severity of ankle fractures, showing that being obese was associated with a greater risk of suffering more severe ankle fractures, especially in the case of obese men under 25 and obese women over 50 years of age. [10] Another study pointed out that a higher BMI resulted in a greater tendency to see ankle fractures, specifically in the fibula in men and bimalleolar and trimalleolar in women[20].

A work recently developed by Gkastaris *et al.,* 2020[4], investigated the association of osteoporosis and bone metabolism. The authors suggested that obesity could have a negative impact on bone health, since low-grade systemic

Table 4. Association between the Body Mass Index and laboratory tests

Variables	Overweight plus obesity* (n=73)		Normal body weight* (n=35)		Total (n=108)		P-value
	n	%	n	%	n	%	
Albumin							
Moderate depletion	1	1.4	0	0.0	1	0.9	-
Mild depletion	2	2.7	2	5.7	4	3.7	
Normal	70	95.9	33	94.3	103	95.4	
Albumin							
Mild and moderate depletion	3	4.1	2	5.7	5	4.6	0.6582[3]
Normal	70	95.9	33	94.3	103	95.4	
*Vitamin D**							
Deficiency	18	24.7	8	22.9	26	24.1	0.7644[2]
Insufficiency	33	45.2	14	40.0	47	43.5	
Normal	22	30.1	13	37.1	35	32.4	
*Vitamin D***							
≤30 *(ng/dl)*	51	69.9	22	62.9	73	67.6	0.4666[2]
>30 *(ng/dl)*	22	30.1	13	37.1	35	32.4	
*Vitamin D****							
<20 *(ng/dl)*	18	24.7	8	22.9	26	24.1	0.8377[2]
≥20 *(ng/dl)*	55	75.3	27	77.1	82	75.9	

* Weight classification by body mass index.
[2] Chi-square Test; [3] Fisher's Exact Test.
Source: * Sociedade Brasileira de Endocrinologia (Brazilian Society of Endocrinology) (Maeda et al, 2014 [19]) and Holick et al., 2011 [20]. ** Sociedade Brasileira de Endocrinologia (Maeda et al, 2014 [19]) and Holick et al. 2011 [20], unifying disability and insufficiency.
*** Sociedade Brasileira de Endocrinologia (Ferreira et al., 2018 [22]).

Table 5. Correlation between BMI and age, CP, vitamin D and albumin (n=108)

Variables	*Coefficient (r) **	*P value*
BMI *vs.* age	0.14966	0.1221
BMI *vs.* calf circumference	0.56516*	<.0001*
BMI *vs.* vitamin D	-0.15352	0.1127
BMI *vs.* albumin	-0.14559	0.1327

BMI: Body Mass Index. * Spearman's correlation coefficient, * p<0.05.

inflammation would likely to be harmful to bones due to the positive regulation of pro-inflammatory cytokines and the increased leptin production observed in obese patients[4].

There are studies showing a strong correlation between BMI and lower limb fractures, associating the excessive increase in body mass with a greater energy transferred to the extremities, which could potentially lead to a fracture[18]. And fractures considered to be of low energy tend to be more severe in obese individuals[18].

Other studies have pointed out that obesity, especially the growth of android fat mass, is strongly associated with pain and the inability to move the feet and the biomechanical and

metabolic mechanisms[21] and a high BMI associated with aging, could also contribute to decreased functionality of the ankle and foot joint[13].

It is also important to highlight the relationship between vitamin D dosages and obesity. It is known that a BMI greater than 30 kg/m^2 could influence vitamin D plasma levels[26, 24], probably due to the solubility of vitamin D in lipid compounds, such as the adipose tissue, reducing its serum quantity and increasing its tissue accumulation[26].

Other investigations have also pointed out an association between vitamin D deficiency and OT, such as, for example, a recent study carried out with 617 patients reporting 40% of patients with vitamin D deficiency, with 11% of the patients having severe deficiency[6]. Another study, however with a smaller sample, showed 47% of patients with vitamin D deficiency and 11% with severe deficiency, with fractures of the foot and ankle[19].

Nutritional status is also another potential risk factor for fractures. A study of 1,055 fractured patients evaluated at different orthopedic institutes in Germany found that 19.5% of them were malnourished[9]. In a study conducted in China, the authors investigated the causes of the high incidence of foot and ankle fractures in the general population and found that BMI> 24kg/m^2 in women was a risk factor[11]. Low serum albumin concentration in conjunction with vitamin D deficiency may also be related to post-fracture and postoperative complications in orthopedic patients, such as pseudoarthrosis and infections, as observed in other studies in the relevant literature[17,14,22].

The population studied here who enjoyed better purchasing power and the private hospital, where this study was conducted, can be considered as the main limiting factors of this investigation. It is suggested that further studies be carried out in patients with OT, in other institutions to better understand these findings.

CONCLUSION

BMI was not found to be associated with metabolic indicators in patients with OT.

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