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# Rotator Cuff Lesion and Obesity: A Demographic and Metabolic Evaluation*

## *Lesão de manguito rotador e obesidade: Uma avaliação demográfica e metabólica*

Saulo Teixeira Pansiere[1,2] Arlane Carvalho de Oliveira[1] Alberto de Castro Pochini[2] Benno Ejnisman[2] Paulo Santoro Belangero[2] Carlos Vicente Andreoli[2]

[1] Instituto de Pesquisa e Ensino do Hospital Ortopédico e Medicina Especializada (IPE-HOME), Brasília, DF, Brazil
[2] Centro de Traumato-ortopedia do Esporte (CETE), Universidade Federal de São Paulo (UNIFESP), São Paulo, Brazil

**Address for correspondence** Saulo Teixeira Pansiere, MD, Hospital Ortopédico e Medicina Especializada (HOME), SGAS Block 613, Conjunto C, Brasília, DF, 70200-730, Brazil (e-mail: saulopansiere@hotmail.com).

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## Abstract

**Objective** To analyze the relationship between the presence and severity of rotator cuff (RC) injury with obesity and the time of exposure to obesity. Secondarily, to evaluate the relationship and prevalence of demographic and metabolic factors in obese individuals with RC injury.

**Methods** This is a cross-sectional study with 235 obese patients (body mass index [BMI] $\geq 30\,kg/m^2$). Demographic data (age and gender), metabolic data (hypertension, diabetes mellitus, lipid profile, and time of exposure to obesity), physical examination (weight, height, waist circumference, and clinical tests), and musculoskeletal ultrasound examination were used to analyze the results.

**Results** There was no evidence of an association between RC injury and BMI ($p = 0.82$), time of exposure to obesity ($p = 0.29$), or abdominal circumference ($p = 0.52$). In the subgroup with injury, age ($p < 0.001$), presence of diabetes mellitus ($p = 0.013$), hypertension ($p < 0.001$), level of high-density lipoprotein (HDL) ($p = 0.026$), and time of exposure to obesity ($p < 0.001$) were significantly greater compared to the subgroup without injury. In the search for other parameters independently associated with RC injury, associations were observed with age ($p = 0.0003$) and hypertension ($p = 0.004$).

**Conclusion** We did not evidence an association between obesity and the time of exposure to it with the occurrence and severity of RC injury. However, individuals with injury had a longer time of exposure to obesity and prevalence of metabolic disorders than individuals without RC injury. In addition, our findings suggest an association between systemic arterial hypertension (SAH) and advanced age with RC injury.

**Keywords**
- rotator cuff
- obesity
- body mass index
- diabetes
- arterial hypertension
- ultrasonography

*Study developed at Centro de Traumato-ortopedia do Esporte (CETE), Universidade Federal de São Paulo (UNIFESP), São Paulo, Brazil.*

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## Resumo

**Objetivo** Analisar a relação da presença e da gravidade da lesão do manguito rotador (MR) com a obesidade e o tempo de exposição à obesidade. De forma secundária, avaliar a relação e a prevalência de fatores demográficos e metabólicos em indivíduos obesos com lesão do MR.

**Métodos** Trata-se de um estudo transversal, com 235 pacientes obesos (índice de massa corporal [IMC] $\geq 30\,kg/m^2$). Dados demográficos (idade e gênero), metabólicos (hipertensão, diabetes mellitus, perfil lipídico, e tempo de exposição à obesidade), exame físico (peso, estatura, circunferência abdominal, e testes clínicos), e exame ultrassonográfico musculoesquelético foram utilizados para a análise dos resultados.

**Resultados** Não foi evidenciada associação da lesão do MR com IMC ($p = 0,82$), tempo de exposição à obesidade ($p = 0,29$), ou circunferência abdominal ($p = 0,52$). No subgrupo com lesão, a idade ($p < 0,001$), a presença de diabetes mellitus ($p = 0,013$), a hipertensão ($p < 0,001$), o nível de lipoproteína de alta densidade (*high-density lipoprotein*, HDL, em inglês) ($p = 0,026$), e o tempo de exposição à obesidade ($p < 0,001$) foram significativamente maiores em comparação ao subgrupo sem lesão do MR. Na busca por demais parâmetros associados de forma independente para lesão do MR, foram observadas associações com idade ($p = 0,0003$) e hipertensão ($p = 0,004$).

**Conclusão** Não evidenciamos associação da obesidade e do tempo de exposição a ela com a ocorrência e a gravidade da lesão do MR. Porém, indivíduos com lesão apresentaram maior tempo de exposição à obesidade e prevalência de disfunções metabólicas do que indivíduos sem lesão. Além disso, nossos achados sugerem uma associação entre hipertensão arterial sistêmica (HAS) e idade avançada com a lesão do MR.



**Palavras-chave**

- manguito rotador
- obesidade
- índice de massa corporal
- diabetes
- hipertensão arterial
- ultrassonografia


## Introduction

Obesity, which is defined by the World Health Organization (WHO) as abnormal or excessive accumulation of body fat, is considered a public health problem due to its high prevalence and associated consequences.[1–3] The incidence of this condition has increased exponentially in recent years, reaching more than 10% of the world population.[4] In Brazil, between 2006 and 2018, there was an increase of more than 67% in the number of obese individuals.[5]

Research has shown that the increase in body mass index (BMI) is an important factor related to chronic metabolic diseases (type-2 diabetes mellitus [DM2], systemic arterial hypertension (SAH) and dyslipidemia)[6–8] and certain disorders of the musculoskeletal system.[9–11] Excess body weight is associated with an increased risk of developing cardiovascular diseases and early onset of cardiac morbidity.[1,6–8] The variables to assess obesity, such as the BMI and abdominal circumference, are considered independent and modifiable factors associated with SAH, DM2 and dyslipidemia.[1,2,12]

In addition to these correlations that have already been scientifically disseminated, obesity seems to contribute to tendon lesions, such as those to the rotator cuff (RC), predisposing the tendon to degeneration and rupture.[9–11,13] The biological plausibility for such an association may be linked to the release of proinflammatory adiponines, leading to oxidative stress and a state of chronic systemic inflammation.[9,14] Other metabolic (DM and SAH) and demographic (age and gender) factors are also considered potentially associated with the causality or worsening of tendinopathies, thus being the focus of recent studies.[15,16] The tendon in diabetic individuals is characterized by increased thickness and volume, with disorganization of the collagen fibers.[17,18] Such abnormalities seem to be the result of decreased peripheral blood flow and local angiogenesis.[15] In addition, SAH-related damage, such as microvessel injury, may aggravate vascular deficiencies in the critical RC zone, leading to hypoxia and the production of reactive oxygen species, culminating in cellular apoptosis and tissue degeneration.[19,20]

Despite these findings, there is still a scarcity in the scientific literature regarding studies that establish a relationship among high BMI ($> 30\,kg/m^2$), abdominal circumference, and the time of exposure to obesity with lesions to the RC tendons in different populations in Brazil. Moreover, scientific controversy on this topic still exists, since other studies have not reported such an association (between obesity and RC lesions).[21,22] Similarly, the relationship among RC lesions in obese individuals and metabolic and demographic factors are not yet fully established.

Therefore, we firstly hypothesize that the occurrence and severity of RC injuries are associated with obesity (assessed by BMI and abdominal circumference) and the time of

exposure to obesity. Secondly, we believe that demographic and metabolic factors are related to RC injuries, and that the prevalence of metabolic dysfunctions is higher among individuals with injuries compared to those without injuries. To test these hypotheses, we conducted a cross-sectional study in obese adult patients.

## Methodology

### Study design and participants

The target population of the present cross-sectional study was composed of men and women who were cared for at the endocrinology and obesity outpatient clinic of our institution between 2018 and 2019.

Patients with BMI $> 30\,kg/m^2$ and aged between 18 and 65 years were included. Volunteers who presented direct risk factors for RC injury, such as previous trauma, smoking, shoulder surgery, glenohumeral instability, chronic corticosteroid use, infiltrations, rheumatoid arthritis, advanced glenohumeral arthrosis, calcareous tendrosis, any other diagnosis of calcification, as well as those who did not agree to sign the Free and Informed Consent Form (FICF) or who did not complete all stages of the study, were excluded from the study.

The sample size (n) required for the study was calculated using the 95% confidence interval and a significance level of 5%, considering the highest variance (25%). The number of patients (one thousand) cared for at our institution in the period of 12 months was relevant, representing the target population. The calculation of the sample size was made based on the estimated proportions.[23] Therefore, in order for the study to have relevance, 235 individuals should be surveyed.

The original sample consisted of 329 individuals. Of these, 94 (28.6%) were excluded because they did not complete all stages of the study, and 235 (71.4%) qualified individuals remained ►**(Figure 1**).

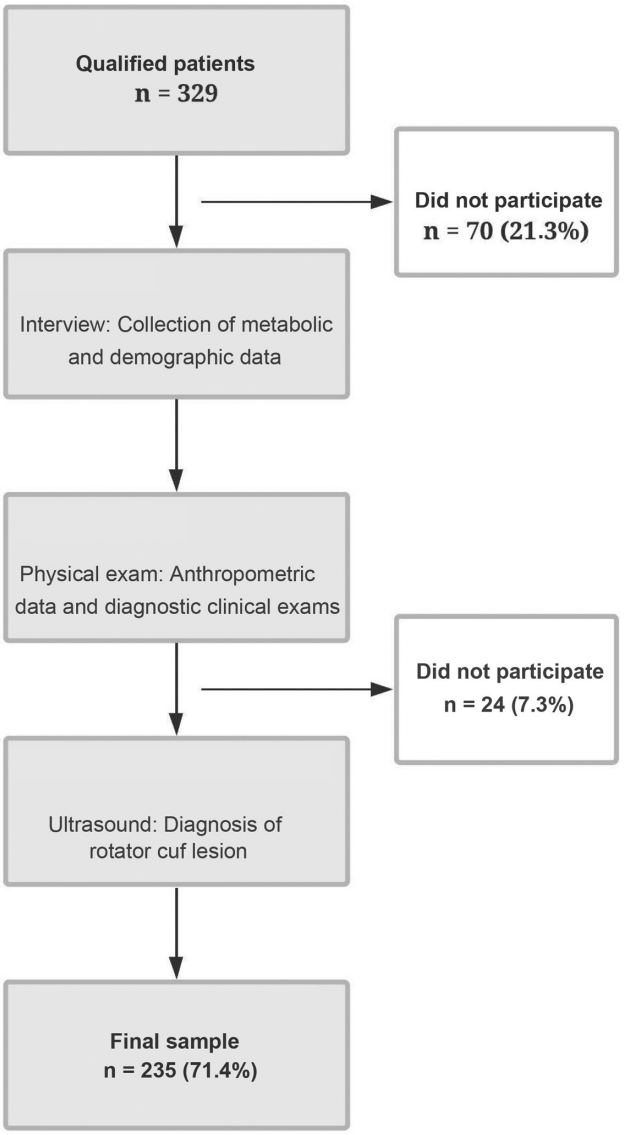


**Fig. 1** Flowchart of the patients in the study.

### Ethical approval

The present research was approved by the Ethics in Research Committee under the opinion number: 3,733,973. All participants were volunteers and signed the FICF, confirming that they were aware of the procedures to be performed and agreed with the research objectives.

### Bias

Caution was taken to avoid misunderstandings regarding the participants' responses. The researchers refrained from making any comments that could lead to answers contrary to the truth conveyed by the patients.

### Data collected and evaluations

The study participants were initially interviewed to collect demographic (age and gender) and metabolic factors (prevalence of SAH, DM, lipid profile and time of exposure to obesity).

The physical examination involved: the evaluation of anthropometric data pertaining to weight and height, which was performed with the patients wearing light clothing and no shoes (based on these data, the individual BMI was calculated); abdominal circumference; and clinical tests to guide the diagnosis of RC injury (the Jobe, Patte and Gerber tests), wich were performed according to their descriptions.[24–26] To close the diagnosis of complete or partial RC injury, a musculoskeletal ultrasound examination was performed bilaterally in all patients, using the protocol established by Selvaraj et al.[27] Ultrasonography is a reliable method, presenting high accuracy in the diagnosis of RC lesions.[28]

The physical examinations of the volunteers were performed by a physician with residency in orthopedics and traumatology, specialized in shoulder/elbow surgery, at the endocrinology and obesity outpatient clinic of our institution. The imaging examinations were performed by a physician specialized in musculoskeletal ultrasonography, with a diploma issued by Associação Médica Brasileira in the field of radiology and diagnostic imaging. Both were independent evaluators, without employment ties to the institutions involved, and were unaware of any information related to the research objectives.

**Table 1** Demographic, metabolic and physical characteristics of the study sample

| | N | Average | (± Standard deviation) |
|---|---|---|---|
| **Demographic factors** | | | |
| Female gender | 157 | | |
| Male gender | 78 | | |
| Age (years) | | 40.5 | 11.1 |
| **Metabolic factors** | | | |
| Low-density lipoprotein (mg/dL) | | 101 | 35 |
| High-density lipoprotein (mg/dL) | | 49.4 | 11.9 |
| Total cholesterol (mg/dL) | | 183 | 38 |
| Systemic arterial hypertension ratio (yes/no) | 85/150 | | |
| Diabetes mellitus ratio (yes/no) | 42/193 | | |
| Time of exposure to obesity (years) | | 11.7 | 8.1 |
| **Physical factors** | | | |
| Weight (kg) | | 102 | 22 |
| Height (cm) | | 166 | 10 |
| Body mass index (kg/m$^2$) | | 36.8 | 5.7 |
| Abdominal circumference (cm) | | 114 | 15 |

### Definitions

The BMI was calculated based on weight in kilograms divided by height in square meters. Obesity was defined as BMI $>$ 30 kg/m$^2$. The analysis of the abdominal circumference was performed with a measurement made 0.5 cm to 1.0 cm above the navel with the subjects breathing naturally. The time of exposure to obesity was calculated considering the first time the participant reached a BMI $>$ 30 kg/m$^2$ (evaluated by analyzing the previous history reported by the patients themselves).

Diabetes mellitus was defined as fasting plasma glucose of 7.0 mmol/L or by a previous diagnosis made by a medical professional. Systemic arterial hypertension was defined according to the following criteria: systolic blood pressure of 140 mmHg, diastolic blood pressure of 90 mmHg, and/or self-reported hypertension. The lipid profile was analyzed based on the levels of total cholesterol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) by a complete lipidogram performed up to six months before the study.

### Statistics

The demographic, metabolic and physical characteristics of the sample were calculated using descriptive statistics, including frequencies, means, and standard deviations (SDs). In order to compare the demographic, metabolic and physical variables of the patients with and without RC injury, two groups were created (with RC injury and without RC lesion) and analyzed using the the Student *t*-test and the Chi-squared test. A multivariate analysis that identified the demographic, metabolic and physical variables associated with RC injury was performed through binary logistic regression with the stepwise variables selection method (step-by-step). Finally, the receiver operating characteristic (ROC) curve was used in order to identify the best cut-off point for the age variable regarding the presence of RC injury. The data were analyzed using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Armonk, NY, US) software, version 26. The level of statistical significance was established at $p < 0.05$.

## Results

The demographic, metabolic, physical characteristics and the profile of RC lesions in the sample are detailed in ►**Tables 1** and **2** respectively.

**Table 2** Profile of rotator cuff lesions of the study sample

| | N | % |
|---|---|---|
| **Presence of injury** | | |
| Yes | 55 | 23.4% |
| No | 180 | 76.6% |
| **Injured limb** | | |
| Right | 32 | 58.2 |
| Left | 7 | 12.7 |
| Both | 16 | 29.1 |
| **Type of injury** | | |
| Partial rupture | 49 | 89.1 |
| Total rupture | 6 | 10.9 |
| **Site of general injury** | | |
| Supraspinal | 47 | 85.5 |
| Infraspinal | 6 | 10.9 |
| Subscapularis | 2 | 3.6 |

**Table 3** Comparison of demographic, metabolic and physical factors in relation to the occurrence of rotator cuff injury

| | Rotator cuff injury (n = 55) | | | No rotator cuff injury (n = 180) | | | *p*-value |
|---|---|---|---|---|---|---|---|
| | N | Average | (± Standard deviation) | N | Average | (± Standard deviation) | |
| **Demographic factors** | | | | | | | |
| Female gender | 36 | | | 121 | | | |
| Male gender | 19 | | | 59 | | | |
| Age (years) | | 46 | 11.2 | | 38.6 | 10.4 | < **0.001** |
| **Metabolic factors** | | | | | | | |
| Low-density lipoprotein (mg/dL) | | 100 | 35 | | 101 | 35 | 0.90 |
| High-density lipoprotein (mg/dL) | | 53.4 | 16 | | 48.2 | 10 | **0.026** |
| Total cholesterol (mg/dL) | | 186 | 40 | | 182 | 37 | 0.54 |
| Systemic arterial hypertension ratio (yes/no) | 33/55 | | | 52/180 | | | < **0.001** |
| Diabetes mellitus ratio (yes/no) | 16/55 | | | 26/180 | | | **0.013** |
| Time of exposure to obesity (years) | | 15 | 9.1 | | 10.7 | 7.5 | < **0.001** |
| **Physical factors** | | | | | | | |
| Weight (kg) | | 102 | 21 | | 102 | 22 | 0.94 |
| Height (cm) | | 165 | 10 | | 167 | 11 | 0.38 |
| Body mass index (kg/m$^2$) | | 37.2 | 5.5 | | 36.6 | 5.7 | 0.54 |
| Abdominal circumference (cm) | | 114 | 15 | | 115 | 15 | 0.88 |

Note: The values in bold indicate a statistically significant difference.

### Comparison of demographic, metabolic and physical factors in obese individuals with and without rotator cuff injury

The data showed that, in the subgroup with injury, age ($p < 0.001$), presence of DM ($p = 0.013$), SAH ($p < 0.001$), HDL level ($p = 0.026$) and time of exposure to obesity ($p < 0.001$) presented significantly higher results compared to those of the group without RC lesion (►**Table 3**).

On average, the individuals with RC injury were 7.4 years older, and had higher prevalences of SAH and DM, of 31.3% and 15% respectively, in addition to about 4.3 years more of exposure to obesity.

### Association between rotator cuff injury and obesity

In the evaluation by binary logistic regression (►**Table 4**), no association was found regarding RC injury and BMI ($p = 0.82$), time of exposure to obesity ($p = 0.29$), or abdominal circumference ($p = 0.52$) in the sample studied. In addition, there was no significant correlation regarding BMI (rs = -0.029; $p = 0.83$), time of exposure to obesity (rs = 0.061; $p = 0.66$), and the severity of the RC lesion.

### Association between demographic and metabolic factors with rotator cuff injury

In the search for other independently-associated (demographic and metabolic) parameters for RC injury, an association was observed between age ($p = 0.0003$) and SAH ($p = 0.004$) (►**Table 4**), thus demonstrating that the older the age and presence of SAH, the higher the probability of RC injury. Using the ROC methodology, with a sensitivity of 65.5% and a specificity of 66.7%, we determined that age ≥ 43 years was a cutt-off point fot the presence of RC injury (►**Figure 2**).

## Discussion

The relationship between obesity and musculoskeletal system injuries, such as tendinopathies, is the focus of scientific studies and controversies.[9–11,13,21] Recent studies[11] suggest

**Table 4** Associated parameters for rotator cuff injury evaluated by binary logistic regression

| | Coefficient | Odds ratio | 95% confidence interval | *p*-value |
|---|---|---|---|---|
| **Demographic factors** | | | | |
| Age (years) | 0.057 | 1.06 | 1.03–1.09 | **0.0003** |
| **Metabolic factors** | | | | |
| Systemic arterial hypertension | 0.984 | 2.68 | 1.38–5.20 | **0.004** |

Notes: The values in bold indicate a statistically significant difference. The selection method for the variables was advanced step by step, at a level of 5%.

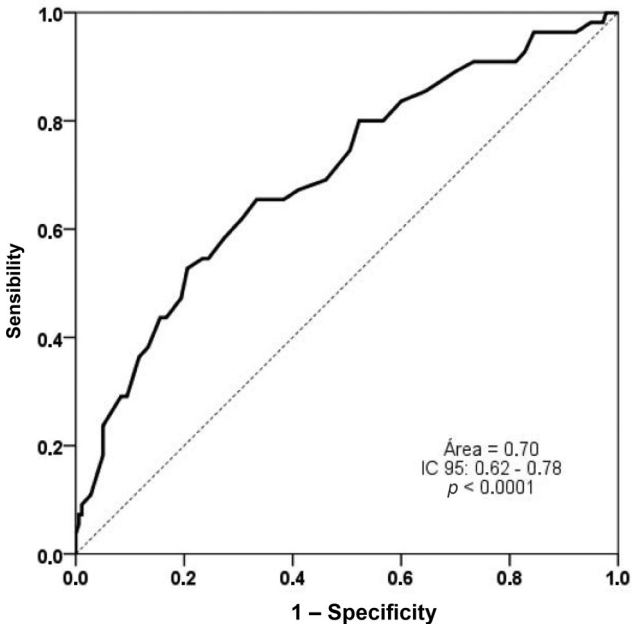


**Fig. 2** Receiver operating characteristic (ROC) curve. Identification of the cut-off point for the age variable for the presence of rotator cuff lesion: $\geq$ 43 years.

an important association between tendon lesions and other metabolic disorders (SAH and DM).

Therefore, we firstly analyzed the relationship regarding the presence and severity of RC injury and obesity and the time of exposure to obesity. Secondly, we evaluated the relationship and prevalence of demographic and other metabolic factors in obese individuals with RC injury. In the present cross-sectional epidemiological study, no associations were found regarding the occurrence and severity of the RC injury and BMI, abdominal circumference and the time of exposure to obesity. However, individuals with injury presented a longer time of exposure to obesity and a higher prevalence of metabolic diseases (SAH and DM) than patients without injury. Finally, SAH and advanced age were factors related to the presence of RC lesion.

The highest susceptibility to ruptures and tendon degeneration in individuals with high BMI and abdominal circumference values has a physiological explanation linked to increased adipokine production (tumor necrosis factor-alpha, leptin, adiponectin, angiotensinogen, and interleukins 6, 8, 10 and 18), leading to oxidative stress, inflammation, endothelial dysfunction and cellular apoptosis.[9,11,14] The first case-control study to establish such a clinical association of the occurrence and severity of RC lesions and obesity was conducted by Gumina et al.[9] The authors evaluated 381 patients, demonstrating that individuals with a mean BMI of 30 kg/m$^2$ presented more than twice the number of lesions as non-obese individuals. Moreover, the higher the BMI measured, the higher the degree of RC lesions evidenced. However, Titchener et al.,[22] in a study with a large sample (5,000 patients), concluded that only overweight (25.1 kg/m$^2$ to 30 kg/m$^2$) was significantly associated with RC injury. In the present study, focused only on individuals with BMI $>$ 30 kg/m$^2$, we found that obesity was not an associated factor for the prevalence or severity of RC injury. In addition, we evidenced an anticipation in the mean (46 years) and cutoff point (43 years) of age for the appearance of tendon ruptures from 12 to 15 years, when compared to previous studies.[29] Yamaguchi et al.[29] demonstrated that the mean age for the occurrence of some level of rupture is 58 years, and 68 years for total rupture. The fact that our sample contains only obese individuals may be an explanation for the difference observed, and suggests that obesity anticipates the appearance of tendon ruptures.

Similarly, high blood sugar levels have an influence on tendon health.[17] Severe ruptures are six times more common in the presence of more than one cardiovascular risk factor, such as DM and SAH.[20] Our results demonstrate a higher prevalence of metabolic dysfunctions (DM, SAH) in patients with RC injury, and an important association between SAH and tendon injury. Decreased angiogenesis, fibroblast proliferation, collagen synthesis and release of growth factors are deleterious results observed in diabetic tendons, decreasing the biomechanical capacity of the tissues and increasing the predisposition to the development or worsening of tendinopathies.[17,18] In a study involving ultrasound RC analysis in patients with diabetes, Abate et al.[30] demonstrated that even asymptomatic individuals have more advanced degeneration patterns, especially in the supraspinatus tendon, than individuals without a diagnosis of diabetes. Gumina et al.,[19] in a study involving 400 patients, concluded that hypertensive individuals were 2 to 4 times more likely to suffer large (involving an entire tendon) and massive (more than 2 tendons) ruptures of the RC compared to normotensive individuals. The main explanations for this important evidence are the state of tendon hypoxia generated by the hypertensive mechanism,[20] even in individuals undergoing pharmacological treatment, since most hypertensive drugs seem to have greater effect on large vessels, maintaining hypoxia in the tendinous tissue and thus favoring tissue degeneration.[19]

The findings of the present study should be treated with caution due to the methodological limitations. Large-scale case-control and cohort studies are needed to obtain an accurate estimate of the prevalence/incidence and associations of demographic, metabolic and physical factors with the risk of developing RC. In addition, these results should be extrapolated to the general population with care, since the study sample was limited to patients from a specific outpatient clinic. We advocate the need for future studies to maximize the analysis not only of obesity, but also of the chronic effect of this comorbidity (exposure time), as a determining factor in the generation of musculoskeletal dysfunctions.

## Conclusion

There was no association regarding obesity and time of exposure to obesity and the occurrence and severity of RC injury. However, individuals with lesions had longer exposure to obesity and higher prevalence of metabolic dysfunctions (DM and SAH) than individuals without RC injury.

Furthermore, our findings suggest an important association regarding SAH and advanced age and RC injury in this population of obese individuals.

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Conflict of Interests
The authors have no conflict of interests to declare.

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