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Original article

Which is the best cutoff of body mass index to identify obesity in female patients with rheumatoid arthritis? A study using dual energy X-ray absorptiometry body composition

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ABSTRACT

Introduction: Standard anthropometric measures used to diagnose obesity in the general population may not have the same performance in patients with rheumatoid arthritis.
Objective: To determine cutoff points for body mass index (BMI) and waist circumference (WC) for detecting obesity in women with rheumatoid arthritis (RA) by comparing these standard anthropometric measures to a dual-energy X-ray absorptiometry (DXA)-based obesity criterion.
Patients and method: Adult female patients with more than six months of diagnosis of RA underwent clinical evaluation, with anthropometric measures and body composition with DXA.
Results: Eighty two patients were included, mean age 55 ± 10.7 years. The diagnosis of obesity in the sample was about 31.7% by BMI, 86.6% by WC and 59.8% by DXA. Considering DXA as golden standard, cutoff points were identified for anthropometric measures to better approximate DXA estimates of percent body fat: for BMI value ≥ 25 kg/m^2 was the best for definition of obesity in female patients with RA, with sensitivity of 80% and specificity of 60%. For WC, with 80% of sensitivity and 35% of specificity, the best value to detect obesity was 86 cm.

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Conclusion: A large percentage of patients were obese. The traditional cutoff points used for obesity were not suitable for our sample. For this female population with established RA, BMI cutoff point of 25 kg/m^2 and WC cutoff point of 86 cm were the most appropriate to detect obesity.

Qual o melhor ponto de corte de índice de massa corporal para diagnosticar a obesidade em mulheres com artrite reumatoide? Um estudo que usa a composição corporal pela absorciometria com raios X de dupla energia

Palavras-chave:
Artrite reumatoide
Obesidade
Densitometria óssea
Composição corporal
Índice de massa corporal

RESUMO

Introdução: Medidas antropométricas universalmente usadas para diagnosticar obesidade na população geral podem não apresentar a mesma performance em pacientes com artrite reumatoide.

Objetivos: Determinar pontos de corte do índice de massa corporal (IMC) e da circunferência de cintura (CC) para detecção de obesidade em mulheres com artrite reumatoide (AR) por meio da comparação dessas medidas antropométricas habituais com os índices de adiposidade obtidos pela densitometria óssea por dupla emissão de raios X (DXA).

Pacientes e método: Mulheres adultas com mais de seis meses de diagnóstico de AR foram submetidas a avaliação clínica com medidas antropométricas e à DXA com exame da composição corporal.

Resultados: Foram incluídas 82 pacientes, média de 55± 10,7 anos. O diagnóstico de obesidade na amostra foi de 31,7% pelo IMC, 86,6% pela circunferência de cintura e 59,8% pela DXA. Considerando a DXA o padrão-ouro, o valor de IMC acima de 25 kg/m^2 foi o mais adequado para definição de obesidade nas pacientes com AR, apresentou sensibilidade de 80% e especificidade de 60%. Da mesma forma, para a CC, com 80% de sensibilidade e de 35% de especificidade, o valor encontrado foi de 86 cm para se detectar a obesidade.

Conclusão: Foi elevado o porcentual de pacientes obesas. Os pontos de corte tradicionalmente usados para obesidade não foram adequados para nossa amostra. Para essa população de pacientes femininas com diagnóstico de AR, o ponto de corte de 25 kg/m^2 para IMC e de 86 cm para CC foi o mais adequado para definir obesidade.

Introduction

Obesity and rheumatoid arthritis (RA) have been shown to be related in different ways. The first condition seems to be related to an increased risk of development of the second disease. Recent meta-analysis that included 11 studies showed that obese subjects with BMI ≥ 30 kg/m^2 had a higher relative risk for developing RA.[1]

In patients with the established disease, the inflammatory process is able of altering body composition, leading to obesity with increased abdominal fat and loss of lean body mass.[2] This decrease in lean body mass, along with the increase in fat mass and in central obesity, may be related to the increased cardiovascular morbidity and also with functional decline.[3]

In cases of RA, the occurrence of body fat accumulation without a significant increase in body weight is a condition known as rheumatoid cachexia,[4,5] whose estimated prevalence ranges from 10 to 67%.[6] In a setting of chronic inflammation, high levels of cytokines cause metabolic changes, which can result in the alterations above mentioned.[7,8]

Moreover, according to the US Center of Disease Control (CDC),[9] the prevalence of obesity in patients with rheumatoid arthritis is 54% higher than in RA-free individuals. A multicenter study found a prevalence of 18% of obesity in a population with RA,[10] while another study found a prevalence of 31%.[11]

Epidemiological data considered RA as an independent risk factor for cardiovascular disease (CVD), and one of the main causes of death in patients with that disease.[12–14] A meta-analysis of 24 studies of patients with RA showed an increase of 50% in the risk of death from cardiovascular causes in general.[15]

Obesity can contribute to increasing the risk of CVD development as well as of type II diabetes mellitus (DM II), dyslipidemia, and hypertension (HBP).[16,17]

Overweight in RA patients has been associated with increased mortality, increased pain, worse quality of life, an increase in indications for the use of joint prostheses, and increased costs with the disease.[18,19] Obesity can also

negatively influence the course of the disease, functional capacity of patients, as well as disease activity.[18,20] Obese patients are not-so good respondents to the use of anti-TNF agents, and are less likely to achieve remission with the use of these drugs.[21] One study found a decreased response to treatment with a combination of synthetic disease-modifying anti-rheumatic drugs in patients with high BMIs.[22]

Obesity, defined as an increase in fat in sufficient level to cause adverse health consequences, is usually diagnosed by anthropometric measurements of body mass index (BMI), which is calculated as weight in kilograms divided by the square of height in meters (kg/m^2), and of waist circumference (WC).[23]

BMI is easy to perform and a good indicator of obesity, but does not have an accurate correlation with body fat. This indicator is not able to distinguish between fat mass and lean mass, and do not necessarily reflects the distribution of body fat.[24] Identifying fat distribution is important in the evaluation of overweight and obesity, as visceral (intra-abdominal) fat is a risk factor for CVD, regardless of total body fat. Individuals with the same BMI may have different levels of visceral fat mass; and this relationship between weight and height may not be able to reflect those body composition changes often found in patients with RA.[8] For a given value of BMI, body fat may differ, and there is evidence of higher percentages of body fat in patients with RA *versus* controls.[25]

Dual-energy X-ray absorptiometry (DXA) is a more accurate method than BMI measurement to assess body composition, both in young and in older subjects; this method is sensitive to small changes in body composition.[26–28] In RA patients, the assessment of body composition by DXA was abnormal, with a decrease in lean body mass and an increase of fat mass, especially in patients within normal range for BMI.[29,30]

The aim of this study is to evaluate the correlation between conventional anthropometric measurements (BMI and WC) and total fat percentage and adiposity indexes obtained through body composition by DXA. Another objective is to identify the need of, and determine, new cutoff points for BMI and WC for obesity detection in women with RA.

Patients and methods

Female patients with rheumatoid arthritis defined according to the American College of Rheumatology (ACR) 1987[31] or to ACR/EULAR 2010[32] classification criteria, with over six months of symptoms, and aged over 18 years old were consecutively invited to participate in this study. Patients with other connective tissue diseases (overlap syndromes), except for secondary Sjögren's syndrome; with presence of a pacemaker, implanted defibrillator, and orthopedic prosthesis, or any metallic object (pins, screws) from orthopedic surgery were excluded from this study, due to interference in body composition examination by DXA. Before performing any procedure, all participants signed a informed consent form (FICF) previously approved by the Research Ethics Committee of UFMG.

All patients underwent clinical evaluation, which included swollen/painful joint counts. Information related to the disease, diagnostic criteria, clinical and laboratory manifestations, the presence of extra-articular manifestations, comorbidities, and current and previous treatments, was obtained from an interview and by medical record review.

Anthropometric measurements and bone densitometry with body composition were performed on the same assessment day. The participants were weighed barefooted and without heavy clothing on a Filizola scale (1–200 kg, with an error margin of 50 g) intended exclusively for weighing people. The subject's height was measured with the stadiometer coupled to the same Filizola scale. The BMI calculation was performed according to the formula: BMI = weight (kg)/height (m^2).

The following BMI ranges were adopted: normal, BMI = 18.5–24.9 kg/m^2; overweight, BMI = 25–29.9 kg/m^2; and obesity, BMI $\geq$ 30 kg/m^2, as recommended by the World Health Organization.[33]

WC was performed using a plastic tape measure, which was applied midway between the lowest rib and the iliac crest with the subject standing, and represented the horizontal distance around the abdomen. Presence of abdominal or central obesity was considered in women whose waist circumference $\geq$ 80 cm.[34]

We also calculated the conicity index, which is another way to estimate abdominal obesity. This index was developed from a geometric ratio model, and was calculated using the patient's waist circumference, weight and height through the following formula:[35]

$$\frac{\text{waist circumference(cm)}}{0.109 \times \sqrt{\frac{\text{weight(kg)}}{\text{height(m)}}}}$$

Body composition was measured by DXA (Discovery W Hologic densitometer [Bedford, MA, USA], v. 3.3.0), and the results were always interpreted by the same trained researcher. The measurements were performed with the subject supine, after removing all metal fittings, and lasted six minutes. We used Bray GA's definition of obesity by DXA, that considers the patient's gender and age group. In this definition, the percentage of fat considered representative of obesity varies from 39 to 43% in women, according to their age group.[36]

Statistical analysis

The descriptive analysis was performed using mean and standard deviation for continuous variables and percentages for binary variables. Anthropometric variables were correlated (Spearman method) to total fat percentage observed with DXA. The optimal cutoff points of anthropometric variables were determined using ROC curves, and with the finding of points that determined preset sensitivities of 80% and 90% for detection of obesity diagnosed with DXA.

The calculations were performed using the R software v3.1.2[37] and ROC curves were plotted using ROCR library.[38]

Table 1 – Demographic and clinical characteristics of study population.

Demographics and factors related to disease	$n = 82$
Age (years) – mean (SD)	55.24 (10.77)
Disease duration (years) – mean (SD)	16.89 (9.08)
Extra-articular manifestations (%)	16.0 ($n = 75$)
Fatigue (%)	32.9
DAS28 – median (quartile 1; quartile 3)	3.9 (3.0; 5.2)
HAQ – median (quartile 1; quartile 3)	1.0 (0.2; 1.6)
RA, seropositive (%)	79.2 ($n = 72$)
Anthropometric data	
Weight (kg) – mean (SD)	65.48 (12.29)
Height (cm) – mean (SD)	154.90 (6.79)
Waist circumference (cm) – mean (SD)	93.99 (12.20)
BMI (kg/m^2) – mean (SD)	27.20 (4.30)
Total fat obtained by DXA (%) – mean (SD)	42.78 (5.23)
Obesity – DXA (%)	59.8
Obesity – BMI (%)	31.7
Obesity – waist circumference (%)	86.6
Inflammatory activity	
ESR (mm/h) – median (quartile 1, quartile 3)	21.5 (14.0; 35.5)
CRP (mg/L) – median (quartile 1, quartile 3)	9.2 (5.9; 17.0)
Comorbidities	
Smoking (%)	29.3
Hypertension (%)	58.5
Diabetes mellitus (%)	15.9
Dyslipidemia (%)	48.8
Metabolic syndrome (%)	51.2
Medications	
Lipid-lowering agents (%)	39.2 ($n = 74$)
Anti-hypertensives (%)	59.8
Anti-diabetic drugs (%)	14.6
Anti-TNF agents (%)	18.7 ($n = 75$)
NSAIDs, regular use (%)	20.0 ($n = 75$)
Biologicals (including anti-TNF) (%)	23.5 ($n = 68$)
Prednisone (%)	63.4
Prednisone dose (mg/day) – median (quartile 1, quartile 3)	5.0 (5.0; 10.0)

DAS28, Disease Activity Score; HAQ, Health Assessment Questionnaire; RA, rheumatoid arthritis; BMI, body mass index; DXA, dual-energy X-ray absorptiometry; ESR, erythrocyte sedimentation rate; TNF, tumor necrosis factor; NSAIDs, nonsteroidal anti-inflammatory drug.
Standard deviation in parentheses for continuous variables.

Ethics

This study was approved by the Research Ethics Committee of Universidade Federal de Minas Gerais (UFMG) on January 10, 2012, with an addendum and FICF approved on February 20, 2013.

Results

Eighty-two women with mean age 55 ± 10.7 years and mean disease duration of 16 ± 9.08 years, were included in this study.

Table 2 – Spearman correlation between anthropometric measurements for waist circumference and body mass index and total fat percentage obtained by DXA.

	Women ($n = 82$)
Waist circumference (cm)	0.482[+]
BMI (kg/m^2)	0.510[*]

[+] $p < 0.05$.
[*] $p < 0.001$.

Table 3 – Sensitivity and specificity BMI (kg/m^2) in obesity detection diagnosed by DXA. Usual cutoff point (BMI = 30) and optimal points found.

	Women ($n = 82$)	
BMI	Specificity	Sensibility
30	76%	37%
25	58%	82%
23	36%	92%

This cohort had a mean BMI of 27.2 ± 4.3 kg/m^2, a mean waist circumference of 94 ± 12.2 cm, and a mean conicity index of 1.33. The demographic characteristics and factors related to the disease are listed in Table 1. The obesity rate found varied according to different criteria: 31.7% by BMI, 86.6% by WC, and 59.8% by DXA. The correlations between the following clinical variables were evaluated: disease duration, DAS28, HAQ, CRP, ESR and cumulative dose of prednisone, both with BMI and with body fat by DXA. None of these correlations was statistically significant.

Table 2 shows Spearman correlations between total fat percentage obtained by DXA and WC and BMI. One can perceive that all correlations obtained were significant ($\alpha = 5\%$) and BMI correlated more strongly with total fat percentage obtained by DXA *versus* by WC. The correlation between conicity index and total fat by DXA was also positive, with statistical significance (+0.2350 with $p = 0.019$); however, this value was lower than that for the correlation with BMI.

To determine the optimal cutoff points of BMI and WC for obesity detection in patients with RA, the construction of ROC curves showed cutoff values presenting 80% and 90% of sensitivity. The ROC curves show that, for the desired sensitivity values, BMI is a better discriminator of obesity than WC, thanks to its higher specificity for the same sensitivity values.

The cutoff point normally used for BMI in assessing obesity (BMI = 30 kg/m^2) showed low sensitivity for detecting disease in this sample (Table 3), identifying only 37% of obese patients in the analyzed group. One can observe that a cutoff around 25 would be more appropriate for patients with RA, as this value has a high sensitivity (80%) with specificity around 60%. Regarding WC, the cutoff point of 80 cm for women is very sensitive (96%), but lacks specificity (only 18%) (Table 4). The WC cutoff point for detecting obesity with 82% of sensitivity is 86 cm. This cutoff point has a specificity of 36%.

Table 4 – Sensitivity and specificity of waist circumference (cm) in obesity detection diagnosed by DXA. Usual cutoff point (80 cm for women) and optimal points found.

Women ($n = 82$)		
Waist circumference	Specificity	Sensibility
80	18%	96%
86	36%	82%
82	27%	92%

Discussion

The obesity rate in this population of patients with RA was high; about one third with the use of the BMI definition, 60% by DXA, and more than 80% according to WC. The study by Giles et al.[30] reported that 33% of women and 36% of men with RA were regarded as obese by BMI, and 57% of these patients were deemed obese by DXA. Katz et al. have described obesity by BMI in 28.4%; on the other hand, these authors reached 58.2% by DXA in the population studied.[39] In relation to obesity frequency by WC, the value found was higher than that described in the literature.[24] With the use of WC, Katz et al. used the obesity criterion of 88 cm for women,[39,40] whereas the present study used a cutoff point of 80 cm by WC – a level more recently recommended by the International Diabetes Federation (IDF) in 2006.[34]

When using DXA as the gold standard for detection of obesity, we realize that the prevalence of this condition was underestimated by BMI and overestimated by WC. The use of a BMI > 30 kg/m^2 had a sensitivity < 40%; and the use of WC > 80 cm for women showed specificity < 20%, clearly an overestimate of the number of obese women in the study group.

One possible explanation for the underestimation seen with the use of BMI is that this indicator lacks the ability to consider the loss of lean body mass concomitantly to fat mass gain in individuals with RA. As for WC, it may be that its recommended threshold for women is unreasonably low (80 cm), a value which lacks specificity.

In determining the cutoff points of BMI and WC for this female population with RA, we employed sensitivity values of 80 and 90%, because our understanding is that these anthropometric measurements should be used to screen patients with RA; therefore, a high sensitivity is a critical factor. Then, we compared our findings to those commonly used as cutoff points of BMI and WC, achieving the new cutoff points suggested in the results.

Our results suggest the use of a BMI > 25 kg/m^2 as the threshold for women, because this value resulted in a sensitivity of 82% and in a specificity of 58% in the diagnosis of obesity. For WC, we suggest the use of 86 cm for definition of obesity, resulting in 82% of sensitivity and 36% of specificity.

The results found in this study are in line with those of other authors who suggest reviewing cutoff points of BMI and WC in patients with RA. Katz et al. proposed a cutoff point for obesity in women of 26.1 kg/m^2 for BMI and of 83 cm for WC.[24] Stavropoulos-Kalinoglou et al. suggested a decrease of 2 kg/m^2 in BMI for RA patients, in order to establish the presence of obesity.[4] In this way, one perceives a universal acceptance of the concept that obesity in RA patients must be handled in an early and intensive manner. Loss of muscle mass and fat infiltration in the muscle, resulting from inflammation, may explain the higher percentage of fat, despite a BMI value within the normal range.

One limitation of our study is its sample size; this suggests that the results obtained are waiting for external validation. The non-inclusion of male patients is another important limitation. It is noteworthy, however, that the prevalence of female patients seems to constitute the absolute majority in RA cohorts in our population. In the multinational cohort of Latin-American patients (GLADAR), the prevalence of female patients was 85%.[41] Another aspect to consider is that in our study a group of patients was excluded for lacking the ability to be examined by DXA; this may have left out a group of patients with comorbidities, or with a disease of greater severity.

This sample consisted of patients with long disease duration (mean, 16 years) and high prevalence for use of corticosteroids (63.4%). The statistical analysis showed no correlation between disease duration or cumulative dose of corticosteroids with BMI or with total fat percentage measured by DXA. In our study, it was found that body fat is increased in a group of long-term RA patients, and other authors have demonstrated that even patients with early RA have their total fat increased when measured by DXA *versus* controls.[42]

Conclusions

Considering DXA as the gold standard, the cutoff points conventionally used for obesity through anthropometric indexes were not suitable for our RA patients.

BMI was the best predictor of obesity in patients with RA *versus* WC, showing a better correlation with total fat percentage obtained by DXA. BMI values above 25 kg/m^2 suggest alertness to optimize the treatment by strengthening the goals for steroid discontinuation, to fight against sedentary lifestyle, and nutritional guidance.

It is suggested that this new BMI cutoff point should be adopted in clinical practice when approaching female patients with RA, in order to identify those overweight subjects and also to promote intensive interventions for better cardiovascular outcomes.

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Conflict of interests

The authors declare no conflicts of interest.

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