Clinical Nutrition ESPEN xxx (2017) e1–e5

Contents lists available at ScienceDirect

Clinical Nutrition ESPEN

journal homepage: http://www.clinicalnutritionespen.com

Original article

Sarcopenic obesity and health outcomes in patients seeking weight loss treatment

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A R T I C L E I N F O

Article history:
Received 11 August 2017
Accepted 4 December 2017

Keywords:
Body composition
Sarcopenic obesity
BIA
Bariatric surgery

S U M M A R Y

Aim: To investigate the prevalence of sarcopenic obesity (SO) and its association with health outcomes in patients seeking weight loss treatment from a bariatric center.
Methods: In this retrospective study, patients [≥18 years old, body mass index (BMI) ≥30 kg/m^2] from the Tallahassee Memorial Bariatric Center and with baseline body composition assessment by bioelectrical impedance analysis were included. Fat mass index (FMI = fat mass/height^2) and fat-free mass index (FFMI = fat free mass/height^2) were calculated. SO was defined by a FMI/FFMI ratio greater than the 95 percentile of sex, BMI and ethnicity specific population-representative references. Medical records were reviewed for biochemical and comorbidity measures.
Results: One hundred and forty-four patients (~69% females, mean age 55.6 years, mean BMI 46.6 kg/m^2) were included. Patients' FMI/FFMI ratios ranged from 0.35 to 1.60 kg/m^2 across body weight spectrum, with 51% having SO. Blood pressure, fasting glucose, triglycerides, HDL or LDL were not different between patients with and without SO. However, the prevalence of high cholesterol, asthma, alcoholism and hernia were higher in patients with SO. SO was the strongest univariate predictor of high cholesterol (OR = 2.08, 95% CI 1.07–4.04) and asthma (OR = 2.77, 95% CI = 1.12–6.83).
Conclusion: SO was prevalent and associated with adverse health outcomes, beyond that captured by anthropometric measures in the present study.

1. Introduction

Obesity is a disease with a rapidly increasing incidence and prevalence. The Center for Disease Control and Prevention reported 36.5% American adults were obese during 2011–2014 [1]. The consequences of obesity are multiple, including an increased risk for all-cause mortality, as well as significant medical and psychological co-morbidities. As such, approximately 196,000 Americans with obesity opted to undergo bariatric surgery for weight control in 2015 as this procedure has been shown to be the most effective and durable treatment for clinically severe obesity [2,3]. Despite having high body weight, individuals with obesity can have low muscularity and/or strength, called sarcopenia. This condition is associated with a number of adverse health outcomes, such as physical disability and impaired physical function [4,5]. The concurrence of sarcopenia and obesity, termed as sarcopenic obesity (SO), is

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https://doi.org/10.1016/j.clnesp.2017.12.004
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associated with even higher risk for poorer outcomes compared to either condition alone, such as metabolic syndrome, insulin resistance, cardiovascular diseases [6] and disability [7], as well as lower physical function [8], infectious complications [9] and higher mortality [10].

Defining SO can be challenging, particularly in younger adults as research has primarily focused on relatively older (aged > 60 years) and less severely obese individuals with no widely accepted criteria [11–13]. A sound previously proposed criterion relates to the use of a ratio between body weight or fat mass (FM) divided by muscle mass or fat free mass (FFM) [14,15]. As proposed previously, weight gain normally occurs alongside a variable rate of accretion of FFM which can potentially give origin to either obesity (normal FFM accretion) or to SO (low FFM accretion) phenotype [16,17]. Therefore, this approach accounts for the proportional differences in FM and FFM. The ratio between these body composition compartments could then be compared with age, sex, body mass index (BMI) and ethnicity specific population-representative reference values for the identification of SO or any other body composition phenotype. Here, we investigated the prevalence and implications of SO defined by the FM/FFM ratio in patients seeking weight loss treatment (pre-bariatric surgery).

2. Materials and methods

Body composition and medical information of patients prior to receiving obesity treatment at the Tallahassee Memorial Bariatric Center from 2012 to 2013 were retrieved. Patients with available body composition measurements, aged ≥18 years and with a BMI ≥30 kg/m^2 were included in this study. Patients treated with oral steroid therapy were excluded as these medications might negatively impact body composition. Information on demographics, blood pressure and biochemical analyses [(glucose, total triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL)] were obtained from laboratory reports if available, as well as medical and psychological comorbidities through self-reported questionnaires.

Body composition [i.e. FM, FFM, body fat percentage (BF%), total body water] was estimated using a Tanita Body Composition Analyzer (model: TBF-310; Tanita Corporation of America Inc. Arlington Heights, IL, USA), under standard procedures. Measurements involving weight were rounded to the nearest 0.1 pound. Height was measured to the nearest 0.1 inch by Accustat Ross Stadiometer. Body mass index was calculated as the ratio of weight (kg)/height squared (m^2) and classified according to World Health Organization categories (Class I obesity, 30.0–34.9 kg/m^2; Class II obesity, 35.0–39.9 kg/m^2; Class III/severe obesity, ≥40 kg/m^2).

Fat mass index (FMI=FM/height^2) and fat-free mass index (FFMI=FFM/height^2) were calculated. This study defined SO as a FMI/FFMI ratio greater than the age, sex and BMI specific cutoff values, which are the 95% percentiles of the FMI/FFMI ratio distribution derived from National Health and Nutrition Examination Survey Database, a population representation sample of North Americans [18], as shown in Table 1.

Table 1
Cutoff values at 95% percentiles of the FMI/FFMI ratio distribution derived from National Health and Nutrition Examination Survey Database [18].

Age (years)	18 to 39.9		40 to 59.9		60 to 69.9		70 to 90	
BMI (kg/m^2)	Men	Women	Men	Women	Men	Women	Men	Women
30 to 39.9	0.57	1.01	0.59	0.93	0.59	0.97	0.61	0.95
≥40	0.86	1.17	0.79	1.10	0.66	1.02	0.69	1.12

Comparisons between SO and non-SO were assessed by independent samples t-test or Mann–Whitney independent samples test for continuous variables, depending on their normal distribution or not. Categorical variables were compared using Chi-square (χ^2) test or Fisher's exact test. Binary logistic regression was used to obtain the odds ratio (OR) and 95% confidence intervals for outcome prediction. All tests were two-sided and statistical significance was reported at the $p \leq 0.05$ level. All analyses were conducted using STATA (version 14.2; StataCorp LP). This study was approved by Florida State University Human Subjects Committee and the Institutional Review Board at Tallahassee Memorial HealthCare, Inc.

3. Results

A total of 144 Caucasian patients were included in this study (age 55.6 ± 11.5 years; 69% female). Average BMI was 46.6 ± 8.4 kg/m^2 and ranged from 31.8 kg/m^2 to 81.3 kg/m^2. The prevalence of severe obesity was 78.5%. There were no sex differences in mean BMI or the prevalence of severe obesity (data not shown). A wide variability of FMI/FFMI ratio, from 0.35 to 1.60 kg/m^2 was observed across the spectrum of body weight, Fig. 1. Females had higher FMI and FMI/FFMI ratio compared to males (24.1 ± 5.3 versus 20.2 ± 7.2 kg/m^2 and 1.1 ± 0.2 versus 0.8 ± 0.3, respectively), whereas males had higher FFMI than females (25.6 ± 4.4 versus 22.7 ± 3.6 kg/m^2). More than half of the patients had SO (50.7%) and these patients had higher BMI, waist circumference, BF%, FMI and FMI/FFMI ratio compared to non-sarcopenic obese individuals, Table 2.

Among patients with available biochemical tests on file, there were no differences in blood pressure, fasting glucose, and lipid profile values (total triglycerides, HDL, LDL) between SO and non-SO patients. Likewise, the prevalence of metabolic syndrome was not different. Patients with SO presented with a higher prevalence of high cholesterol ($p = 0.03$) and asthma ($p = 0.023$). In addition, patients reporting having alcoholism or hernia all had SO. There was a trend for a higher prevalence of anxiety among patients with SO ($p = 0.07$). No difference regarding the prevalence of other comorbidities by SO status was observed.

We further examined the effect of SO, age, sex, smoking, FMI, and FFMI on asthma or high cholesterol in univariate logistic regression analyses. Odds ratios of these variables were presented in Table 3. Only SO predicted asthma (OR = 2.77, 95% CI = 1.12–6.83) and high cholesterol (OR = 2.08, 95% CI = 1.07–4.04). Considering the cut-points that we used to define SO were already stratified by sex, age and BMI, we reported the findings at univariate level. Nevertheless, if age, sex, BMI are included (multivariate analysis), SO remained the only predictor of asthma and high cholesterol (OR = 2.82, 95% CI 1.08–7.33 and OR = 2.90, 95% CI = 1.35–6.24, respectively). Additionally, with adjustment of age and sex, neither FMI nor FFMI alone predicted asthma or high cholesterol.

4. Discussion

Given the serious health consequences of SO and the increasing demand for bariatric surgery as a treatment option, research on understanding SO's impact must continue and advance forward. This retrospective study demonstrated a wide variability in body composition as assessed by the FMI/FFMI ratio in this group of relatively young patients with obesity, illustrating how variable the proportions of fat to fat-free tissues may differ even in patients with similar body weight or BMI. Furthermore, individuals with SO had a higher prevalence of high cholesterol and asthma, and this body composition abnormality was the strongest predictor of high

Please cite this article in press as: Xiao J, et al., Sarcopenic obesity and health outcomes in patients seeking weight loss treatment, Clinical Nutrition ESPEN (2017), https://doi.org/10.1016/j.clnesp.2017.12.004