ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2016;■:■■■-■■■

ORIGINAL RESEARCH

Sarcopenic Obesity in Adults With Spinal Cord Injury: A Cross-Sectional Study

Chelsea A. Pelletier, PhD,[a] Masae Miyatani, PhD,[a] Lora Giangregorio, PhD,[a,b] B. Catharine Craven, MSc, MD, FRCPC[a,c]

From the [a]Toronto Rehabilitation Institute—University Health Network, Brain and Spinal Cord Rehabilitation Program, Toronto, Ontario; [b]Department of Kinesiology, University of Waterloo, Waterloo, Ontario; and [c]Department of Medicine, University of Toronto, Toronto, Ontario, Canada.

Current affiliation for Pelletier: School of Health Sciences, University of Northern British Columbia, Prince George, British Columbia, Canada.

Abstract

Objectives: To describe (1) the frequency and utility of clinically relevant spinal cord injury (SCI)-specific and general population thresholds for obesity and sarcopenic obesity; and (2) the fat and lean soft tissue distributions based on the neurologic level of injury and the American Spinal Injury Association Impairment Scale.

Design: Cross-sectional.

Setting: Tertiary SCI rehabilitation hospital.

Participants: Persons (N=136; men, n=100; women, n=36) with chronic (mean ± SD: 15.6±11.3y postinjury) tetraplegia (n=66) or paraplegia (n=70).

Interventions: Not applicable.

Main Outcome Measures: Body composition was assessed with anthropometrics and whole-body dual-energy x-ray absorptiometry. Muscle atrophy was quantified using a sarcopenia threshold of appendicular lean mass index (ALMI) (men, ≤7.26kg/m^2; women, ≤5.5kg/m^2). Obesity was defined by percentage body fat (men, ≥25%; women, ≥35%), visceral adipose tissue (≥130cm^2), and SCI-specific obesity thresholds (body mass index [BMI] ≥22kg/m^2; waist circumference ≥94cm). Sarcopenic obesity was defined as the presence of both sarcopenia and obesity. Groups were compared based on impairment characteristics using an analysis of covariance.

Results: Sarcopenic obesity was prevalent in 41.9% of the sample. ALMI was lower among participants with motor-complete (6.2±1.3kg/m^2) versus motor-incomplete (7.5±1.6kg/m^2) injuries ($P<.01$). Whole-body fat was greater among participants with tetraplegia (28.8±11.2kg) versus paraplegia (24.1±8.7kg; $P<.05$). Compared with general population guidelines (20.6%), SCI-specific BMI thresholds identified all the participants with obesity (77.9%) based on percentage body fat (72.1%).

Conclusions: The observed frequency of sarcopenic obesity in this sample of individuals with chronic SCI is very high, and identification of obesity is dissimilar when using SCI-specific versus general population criteria.

Archives of Physical Medicine and Rehabilitation 2016;■:■■■-■■■

In the acute and subacute phases of spinal cord injury (SCI), body composition changes are rapid.[1,2] Declines in muscle cross-sectional area coincide with increases in whole-body, intramuscular, abdominal, and visceral fat, which contribute to reduced muscular endurance, premature hyperlipidemia, and glucose intolerance.[3,4] Combined with the impairment-related increased propensity for sedentary behavior, these declines in lean mass and increases in fat mass contribute to a decrease in metabolic rate and a positive energy balance, perpetuating a cycle leading to multimorbidity.[5,6]

Previous studies[7-10] have identified that people with SCI have 8.5% to 13% more adipose tissue per unit body mass than able-bodied controls. Some authors have suggested that up to two

Supported by the Canadian Institutes for Health Research (grant no. 86521), the Craig H. Neilsen Foundation (grant no. 1991150), the Ontario Neurotrauma Foundation (grant nos. 2008-SCI-PDF-692, 2009-SC-MA-684), and the Spinal Cord Injury Solutions Network (grant no. 2010-43), Spinal Cord Injury Ontario, the Ontario Ministry of Research and Innovation, and the Canada Foundation for Innovation.

Disclosures: L.G. has a financial relationship with Icon on behalf of Eli Lilly, outside the submitted work. The other authors have nothing to disclose.

0003-9993/16/$36 - see front matter © 2016 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2016.04.026

thirds (66%) of individuals with SCI are obese, a prevalence of obesity that exceeds that of the general population,[11] while others report more modest obesity estimates of 20%.[12] Although body mass index (BMI) $\geq$30kg/m^2 is the most commonly used definition of obesity in the general population,[13] BMI has been shown repeatedly to underestimate whole-body adiposity among men and women with SCI,[10,14,15] indicating it may not be the most appropriate measure to estimate cardiometabolic health risk in the chronic SCI population.

In recent years, abdominal obesity, specifically visceral adipose tissue (VAT), has garnered considerable attention for its close associations with the metabolic syndrome.[16,17] Abdominal obesity increases after SCI; isolated reports[17] in samples of modest size indicate a 58% increase in VAT in adults with chronic SCI. Waist circumference (WC) has been identified as a valid surrogate for estimating VAT and disease risk in the able-bodied population; however, the validity of this association after trunk muscle paralysis is unclear, and validation studies[17,18] completed to date have been limited by sample size.

Lean soft tissue mass is critically important for its contributions to metabolism and functional independence. Sarcopenia is a term traditionally used to define age-related declines in lean soft tissue mass, area, and quality. Sarcopenia is typically diagnosed as an appendicular lean mass index (ALMI) (appendicular lean soft tissue mass/height^2) that is $\geq$2 SDs below reference values from young, healthy individuals.[19] Declines in muscle mass after SCI are well defined in previous literature and include a decrease in overall cross-sectional area up to 50%,[1,5] preferential atrophy of type I fibers and predominance of type IIb fibers,[10,20] and increased fatty infiltration of muscle.[21] While the criteria for sarcopenia are most commonly used in elderly populations, they have potential utility to identify a clinically relevant level of appendicular muscle atrophy secondary to spinal cord impairment.

Although people with SCI experience both an increase in adiposity and a decrease in lean soft tissue mass, there is a need to quantify a threshold or degree of change indicative of increased cardiometabolic disease risk. Sarcopenic obesity is a disease state defined as decreased muscle mass and excessive fat accumulation, and is a strong predictor of all-cause mortality and performance of activities of daily living in older adults.[22,23] In the general population, sarcopenic obesity has an estimated prevalence of 4% to 12% in men and women older than 60 years.[24,25] Although muscle atrophy and obesity are frequently recognized clinical manifestations of SCI, no prior reports have attempted to describe the frequency or magnitude of these changes in the chronic SCI population based on current clinical diagnostic thresholds.

The primary objectives of this investigation are to (1) describe the fat and lean tissue mass distribution in adults with chronic SCI based on neurologic level of injury (NLI) and the American Spinal Injury Association Impairment Scale (AIS); and (2) identify the frequency of sarcopenia, obesity, and sarcopenic obesity in a large heterogeneous cohort of adults with chronic SCI based on SCI-specific versus general population diagnostic criteria. A secondary objective is to determine whether WC and BMI are associated with visceral and whole-body adipose tissue measures obtained using dual-energy x-ray absorptiometry (DXA).

List of abbreviations:

AIS	**American Spinal Injury Association Impairment Scale**
ALMI	**appendicular lean mass index**
BMI	**body mass index**
DXA	**dual-energy x-ray absorptiometry**
NLI	**neurologic level of injury**
SCI	**spinal cord injury**
VAT	**visceral adipose tissue**
WC	**waist circumference**

Methods

Community-dwelling participants were recruited as part of 2 cross-sectional studies[26,27] at an SCI-specific tertiary rehabilitation hospital (Lyndhurst Center, Toronto Rehabilitation Institute—University Health Network). The methodology of each study is presented elsewhere.[26,27]

Participants were recruited from 2009 to 2013 through poster campaigns, advertisements in SCI stakeholder magazines, and outpatient clinics. Adult participants (aged $\geq$18y) with a chronic SCI (C2—T12, AIS A—D) at least 2 years before enrollment and with the ability to give informed consent were included. Participants were excluded if they had current or prior conditions other than paralysis known to adversely influence bone metabolism, a weight >123kg (densitometer limit), or if they were pregnant or planning to become pregnant. The relevant institutional research ethics board approved study protocols, and informed consent was obtained from each participant.

Demographic and anthropometric data

Medical, impairment, and demographic information (including height [cm]) was obtained through interview and medical chart abstraction, as appropriate. Body weight (kg) was measured using a Stathmos-Lindell Self-indicating Platform Scale[a] or a scale[b] attached to the ceiling lift during transfer from the participant's wheelchair onto the DXA scanning bed. BMI was defined as body mass divided by the square of the height (kg/m^2). WC (cm) was measured in the supine position at the level of the lowest rib.[17]

DXA assessment

Whole-body DXA scans were acquired using a Hologic Discovery W Densitometer[c] (model QDR 4500W) by an International Society for Clinical Densitometry—certified technologist. Whole-body scans were acquired and analyzed using commercially available Hologic software (version 13.4.1:5 Auto Whole Body[c]). All scans were completed using the same densitometer, and quality control checks were completed daily and weekly as indicated by the manufacturer. Outcomes are reported according to International Society for Clinical Densitometry guidelines and include whole-body fat (kg), lean soft tissue mass (kg), percentage body fat, fat mass index (kg/m^2), trunk/limb fat mass ratio, android/gynoid ratio, trunk fat mass (kg), percentage trunk fat, VAT (cm^2), lean soft tissue mass index (kg/m^2), and ALMI (kg/m^2).[28] Whole-body DXA scans have been shown to be highly reproducible among wheelchair athletes.[29] Scans were excluded from full analysis if a movement artifact was present in any limb; only VAT outcomes were included. If a limb was outside the scan borders for the region of interest, values from the contralateral side were replicated.