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Original Research

Anthropometric Prediction of Visceral Adipose Tissue in Persons With Motor Complete Spinal Cord Injury

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Abstract

Background: Spinal cord injury (SCI) results in increased accumulation of visceral adipose tissue (VAT). Anthropometrics may provide an alternative to estimate VAT cross-section area (CSA) compared to magnetic resonance imaging (MRI).
Objective: To validate the use of anthropometrics, including abdominal circumference and skinfold thickness (SF_T) measurements against MRI to predict subcutaneous adipose tissue (SAT) and VAT cross-sectional areas in persons with SCI.
Design: Cross-sectional.
Setting: Clinical research center
Participant: Twenty-two men with motor complete SCI
Methods: Anthropometric measurements and MRI were taken during a single visit. Abdominal circumference and SF_T were used to derive prediction equations for subcutaneous adipose tissue ($SAT_{Anthro\text{-}CSA}$) and VAT ($VAT_{Anthro\text{-}CSA}$). Three-axial MRI at the level of umbilicus was used to establish the prediction equations. $VAT_{Anthro\text{-}CSA}$ was compared against body mass index (BMI), waist circumference, and SF_T. Bland-Altman plots were used to determine limits of agreement between prediction equations and MRI.
Main Outcome Measurements: SAT and VAT cross-sectional areas.
Results: $SAT_{Anthro\text{-}CSA}$ explained 76% of the variance in SAT cross-sectional area (r^2=0.76, standard error of the estimate [SEE]= 49.5 cm^2, P<.001). $VAT_{Anthro\text{-}CSA}$ explained 72% of VAT cross-sectional area (r^2=0.72, SEE=45.8 cm^2, P<.001). Compared to $VAT_{Anthro\text{-}CSA}$, BMI, waist circumference, and SF_T explained only 37%, 63%, and 31%, respectively, in the variance of VAT MRI.
Conclusion: Abdominal circumference and SF_T demonstrated an alternative way to predict VAT CSA. $VAT_{Anthro\text{-}CSA}$ estimated VAT_{MRI} more accurately than BMI, waist circumference, and SF_T in individuals with chronic SCI.
Q3 **Level of Evidence:** ■■■

Keywords: visceral adipose tissue; subcutaneous adipose tissue; anthropometrics; magnetic resonance imaging; spinal cord injury

Introduction

Spinal cord injury (SCI) results in decreased physical activity and deleterious changes in body composition, characterized by increased fat mass and decreased lean mass [1,2]. These body composition changes have been associated with a wide spectrum of metabolic disorders, including dyslipidemia, impaired glucose tolerance, and insulin resistance [2-6]. Studies have shown that increases in central adiposity is negatively associated with altered metabolic profiles in clinical populations, as well as in persons with SCI [7-9]. Trunk adiposity is an example of regional adiposity that is characterized by an increased accumulation of truncal visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) [8,10,11]. VAT has been shown to be 58% greater in persons with SCI compared to waist-circumference matched able-bodied controls [7]. Moreover, VAT was tightly associated with increased fasting plasma glucose, triglycerides, and c-reactive protein in persons with SCI [4,7,8]. These findings emphasize the significance of quantifying VAT to help explain the high prevalence of cardiometabolic abnormalities following SCI [2,12,13].

Advanced imaging technologies such as dual x-ray absorptiometry (DXA), computed tomography (CT), and magnetic resonance imaging (MRI) allow for the quantification of VAT in different populations [14-16]. CT and MRI are considered the gold standard techniques for quantifying VAT [17-19]. However, the risk of ionized

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radiation limits the use of CT to capture multiaxial slices [20] and may promote reliance on the use of a single-axial slice to measure VAT. It is plausible that a single-axial slice overestimates the magnitude of VAT in persons with SCI [10]. Using MRI to measure VAT allows the capture of multiaxial slices [8,10,21]. However, the cost of the scanner/operators and the labor-intensive analysis may limit MRI practicality in a large cohort. Therefore, the search for an alternative approach to predict VAT is of paramount importance, to provide an early detection of metabolic abnormalities after SCI.

Proxy indices similar to BMI and waist circumference are frequently used to identify risk factors associated with abdominal obesity [22-26]. Individuals with SCI accumulate greater VAT at any given BMI or waist circumference compared to able-bodied controls [26]. At BMI of 30, persons with SCI had 43% more VAT than able-bodied controls [26]. However, BMI is not a measure of central adiposity and may underestimate the associated cardiometabolic risk factors. Waist circumference is the most widely used surrogate measure to assess cardiometabolic risk factors associated with abdominal obesity in able-bodied persons and those with SCI [7,19,22-24], and is defined as the narrowest girth across the torso length [19,23]. In able-bodied controls, abdominal obesity is defined as waist circumference greater than 102 cm [25]. However, previous controversial findings were noted about the relationship of waist circumference and VAT in persons with SCI [7,26], emphasizing the need to establish a more accurate and practical assessment tool to predict VAT following SCI and to flag early those who may be at risk of developing cardiometabolic disorders.

Skinfold thickness (SF_T) and thigh circumference have recently been used to predict mid–thigh muscle cross-sectional area (CSA) after accounting for both intramuscular fat and bone CSA in persons with SCI [27]. Thigh circumference was used to measure total thigh CSA, and SF_T was used to account for thigh SAT. The work was successful in developing a field equation that predicted 75% of the variance in the thigh muscle CSA as measured by MRI [27].

The purpose of the current study was to validate the use of anthropometrics, including circumferential and SF_T measurements, against MRI to predict total trunk, SAT, and VAT CSAs in persons with SCI. This will provide an opportunity to develop a field equation capable of predicting central adiposity in individuals with chronic SCI. This anthropometric predictive equation may provide clinicians with a practical assessment method to predict VAT following SCI. We hypothesized that the use of anthropometrics will provide an accurate estimation of central adiposity after SCI.

Methods

Participants

Twenty-two men with motor complete SCI (14 with paraplegia and 8 with tetraplegia) were recruited as a part of a clinical trial NCT01652040 [28]. Participants' characteristics are presented in Table 1. The study protocol was reviewed and approved by the McGuire VA Medical Center Institutional Review Board and all participants provided a written informed consent. Inclusion criteria included age between 18 and 50 years and level of injury C5-T11 motor complete (American Spinal Cord Injury Classification A or B). Persons with the following medical conditions were excluded: cardiovascular disease, uncontrolled or pharmaceutically controlled type II diabetes, active urinary tract infection, and stage 2 or greater pressure ulcer.

Procedures

Study was performed during a single visit at the study site. Participant's anthropometric measurements were taken wearing light clothing and without shoes.

Table 1
Demographic and physical characteristics of 22 persons with motor complete spinal cord injury

	Tetra (n=8)	Para (n=14)	Total (n=22)	Range
Age, years	37 ± 11	37 ± 10	37 ± 10.3	18-50
Height, m	1.80 ± 0.05	1.8 ± 0.06	1.78 ± 0.06	1.66-1.89
Weight, kg	75 ± 14	82± 12	79.57 ± 13.25	56.6-107.5
BMI	24.0 ± 5	25.7 ± 3.4	25.09 ± 4.01	17.1-31.5
Waist circumference, cm	87.5 ± 13	87 ± 12	87 ± 12	71-107
Abdominal circumference, cm	90± 14	88.4 ± 11.6	89 ± 12	63.6-113.2
Abdominal skinfold, cm	4.4 ± 2.5	3.7 ± 1.5	4.0 ± 1.9	1.7-8.7
Suprailiac skinfold, cm	4.4 ± 2.4	3.7 ± 1	4.0 ± 1.6	1.5-8.9
Time since injury, years	8 ± 7	8.6 ± 8.4	8.3 ± 7.8	1-28
Level of injury	C5-C7	T3-T11	C5-T11	C5-T11
Caucasian	6	8	14	—
African American	2	6	8	—

Tetra = tetraplegic; Para = paraplegic; BMI = body mass index.