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Review article

Utilization of non-invasive imaging tools for assessment of peripheral skeletal muscle size and composition in chronic lung disease: A systematic review

Dmitry Rozenberg [a, b], Vanessa Martelli [a, b], Luciana Vieira [c], Ani Orchanian-Cheff [d], Nadia Keshwani [e], Lianne G. Singer [a, b], Sunita Mathur [f, *]

[a] Dept. of Medicine, University of Toronto, Canada
[b] Respirology, Lung Transplant Program, University Health Network, Canada
[c] Clinical Research Centre, Hospital de Base do Distrito Federal, Brasilia, Brazil
[d] Library and Information Services, University Health Network, Canada
[e] School of Rehabilitation Therapy, Queen's University, Canada
[f] Dept. of Physical Therapy, University of Toronto, Canada

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ABSTRACT

Objectives: Non-invasive imaging modalities allow for detailed assessment of peripheral skeletal muscle wasting, which is associated with increased morbidity and mortality in chronic lung disease. Given the increased utilization of imaging tools, a systematic review was conducted using PRISMA guidelines to describe the modalities and acquisition techniques used to evaluate skeletal muscle in chronic lung disease and assess the relationships of muscle size and composition with strength, physical performance, structural alterations and clinical outcomes.

Methods: Six electronic databases were searched (inception-May 2017) to identify prospective studies measuring peripheral skeletal muscle size or composition using computed tomography (CT), magnetic resonance imaging/spectroscopy (MRI/MRS), or ultrasound (US) in adult chronic lung disease patients.

Results: Fifty-eight articles were included, which utilized: CT (n = 26), MRI/MRS (n = 16) and US (n = 16) in 2254 participants. All studies measured muscle size, predominantly of the lower extremity (n = 53), and only nine assessed muscle composition (i.e. fat infiltration) mainly with CT or MRI/MRS (n = 7). Thigh muscle size had a significant association with strength (r = 0.43–0.83, n = 13/14 studies), 6-min walk distance (r = 0.60–0.62, n = 3/6) and physical activity (r = 0.30–0.82, n = 3). Thigh muscle atrophy was independently associated with increased re-hospitalization (n = 1) and mortality (n = 3). Increased muscle fat infiltration had a moderate association with reduced physical performance partly related to increased anaerobic metabolism, but its prognostic utility was not assessed.

Conclusion: Imaging modalities are valuable tools for the characterization of skeletal muscle dysfunction in chronic lung disease in clinical and research settings. The use of muscle imaging as a prognostic marker is promising and requires further study.

Contents

* Corresponding author. Dept of Physical Therapy, University of Toronto, 160-500 University Ave, Toronto, ON, M5G 1V7, Canada.
E-mail address: sunita.mathur@utoronto.ca (S. Mathur).

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Abbreviations

BIA	Bio-electrical Impedance
COPD	Chronic Obstructive Pulmonary Disease
CSA	Cross-sectional Area
CT	Computed Tomography
D-XA	Dual-energy X-ray Absorptiometry
ILD	Interstitial Lung Disease
MRI	Magnetic Resonance Imaging
MRS	Magnetic Resonance Spectroscopy
6MWD	Six-minute walk Distance
US	Ultrasound

1. Introduction

Skeletal muscle wasting is an important extra-pulmonary manifestation of chronic respiratory disease [1]. Decreased skeletal muscle mass has been associated with increased physical disability [2], poor quality of life [3], increased risk for recurrent hospitalizations [4] and mortality [4,5]. Several modalities have been utilized to assess skeletal muscle mass such as bio-electrical impedance (BIA), dual-energy X-ray absorptiometry (D-XA), and imaging technologies such as ultrasound (US), computed tomography (CT), magnetic resonance imaging and spectroscopy (MRI/MRS) [6]. BIA and D-XA utilize differential absorption properties of lean versus fat tissue to estimate whole body or segmental lean body mass [7]. These modalities have widespread use as they are lower in cost and more readily available than other imaging modalities [6]. However, BIA and D-XA cannot be used to measure the size of specific muscle groups, which could help inform our understanding of the relationship between muscle specific atrophy and physical function [6,7].

Imaging modalities (US, CT, and MRI) have widespread application in skeletal muscle mass assessment. CT and MRI are considered the gold standard measures for skeletal muscle size given their ability to distinguish muscle tissue from fat, and obtain regional muscle measurements [6,8]. MRI has some advantages over CT given its superior contrast between muscle and fat, ability to examine muscle architecture (shape, volume) and absence of ionizing radiation; however, it is more costly and requires greater technical expertise [8]. US is emerging as a preferred imaging tool for clinical and research studies given its low cost, portability and absence of radiation. Muscle size from US has been shown to correlate closely with CT [9] and MRI [10] in chronic obstructive pulmonary disease (COPD) patients and healthy individuals, respectively.

CT, MRI and US allow for an accurate, non-invasive assessment of muscle size and composition, which has important functional implications in chronic disease. In fact, qualitative changes such as increased muscle fat infiltration is being increasingly recognized as an important determinant of physical function, independent of muscle size [11]. Increased muscle fat infiltration with imaging has been described in a number of chronic conditions such as diabetes [12] and muscular dystrophy [13]. Imaging provides an opportunity to characterize these intrinsic changes in a non-invasive manner without the need for a muscle biopsy. Furthermore, these modalities offer an opportunity to bridge the gap in our understanding of the relationship between skeletal muscle structure and functional deficits. Identification of chronic lung disease patients at risk of developing skeletal muscle dysfunction could potentially prevent the associated morbidity and mortality through early nutritional [14] and exercise interventions [15].

Given the evolving body of research utilizing imaging to assess skeletal muscle in chronic respiratory disease, this systematic review was performed to address the following three objectives: 1) to describe non-invasive imaging modalities (CT, MRI/MRS or US) and acquisition techniques that have been used to evaluate peripheral skeletal muscle size and composition; 2) characterize the degree of muscle impairment as measured with these modalities; and 3) describe the associations of muscle size and composition with strength, function, structural alterations and bioenergetics, and clinical outcomes in chronic lung disease.

2. Methods

2.1. Study design

Systematic review of studies utilizing any one of CT, MRI/MRS or US to assess skeletal muscle size or composition in chronic respiratory disease. This review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [16]. Given this was a systematic review, no ethics approval was sought.