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Original Article

The relationship between radiological paraspinal lumbar measures and clinical measures of sarcopenia in older patients with chronic lower back pain

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Abstract

Objectives: Sarcopenia is postulated to be an influential factor in chronic low back pain. The aim of this study is to evaluate the relationship between traditional clinical measures of sarcopenia and novel radiographic methods which evaluate overall muscle status, such as adjusted psoas cross-sectional area (APCSA) and degree of fat infiltration (%FI) in paraspinal muscles, in patients with chronic low back pain. **Methods**: Prospective study performed at our institution from 01/01/19-01/04/19. Inclusion criteria were patients ≥65 years old not requiring surgical intervention presenting to a low back pain assessment clinic. **Results**: 25 patients were identified (mean age: 73 years, 62% male). On spearman's analyses, %FI shared a significant relationship with hand grip strength (r = -0.37; p=0.03), chair rise (r=0.38; p=0.03), SC (r=0.64; p<0.01), and visual analogue scale scores (r=-0.14; p=0.02). Comparably, a statistically significant correlation was evident between APCSA and %FI (r=-0.40; p=0.02) on analysis. **Conclusion**: The results of our study demonstrate a statistically significant relationship between APCSA and %FI in the multifidus and erector spinae muscles. Further significant associations of relatability were depicted with traditional clinical measures of sarcopenia. Thus, %FI may be a supplemental indicator of the sarcopenic status of patients presenting with chronic low back pain.

Keywords: Low back pain, Lumbar spine, Radiology, Sarcopenia, Spine surgery

Introduction

Skeletal muscle integrity is an essential aspect of stability, mobility and functional independence in humans. From the fourth decade onwards, muscle mass and force decline as part of the normal aging process[1]. However, the rate and degree to which muscle mass and strength decline are heterogeneous and vary from person to person[2].

Sarcopenia is regarded as a pathological state in which there is significant loss of skeletal muscle mass, strength and function[1,2]. Sarcopenia was only recently classified by the Centre for Disease Control (CDC) and ICD-10 as an independent disease entity[3]. The approximate prevalence of sarcopenia in older people is estimated to between 5-50%, with much higher prevalence in older clinical populations and subsequent adverse effects on quality of life (QoL) and activities of daily living (ADLs), in addition to increased rates of hospitalization and overall mortality[3,4]. Of importance to this study, sarcopenia has been hypothesised as an influential factor in the prevalence of back pain[5,6].

The authors have no conflict of interest.

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To date, several clinical and physical performance measures have been proposed for the clinical identification of sarcopenia, such as handgrip strength, chair rise, gait speed, among others[5]. Such tests are popular due to their reproducibility and comparability among many patient groups. However, there is a lack of consensus regarding the most sensitive measure, and concerns remain as to their inter-test relatability or comparability, especially in older people. This is compounded by acknowledged variations in identification cut-off values for certain patients or populations dependent on clinical or demographic characteristics, as well as rater bias[8-15].

It has been postulated that the age-related mechanisms that are characteristic of sarcopenia are also associated with lower back pain (LBP) in older people[5]. LBP is renowned as a leading cause of disability worldwide with a lifetime incidence of 84%[5]. Despite the high prevalence of LBP, its pathophysiology remains poorly understood. There is an increasing trend towards investigation of the paraspinal muscles (psoas, multifidus, quadratus lumborum, and erector spinae) and their role in influencing the incidence of LBP in older patients[6]. As a result, more modern methods to radiologically evaluate sarcopenia have been developed using computed tomography (CT) and magnetic resonance imaging (MRI). These methods include measuring the cross-sectional area (CSA) or degree of fat infiltration of certain paraspinal muscles[8], such as the psoas, multifidus, and erector spinae muscles[9,11]. The cross-sectional area (CSA) of the psoas, respectively adjusted for height (APCSA), has been shown to be a good indicator of overall muscle mass[9]. Therefore, APCSA quantification is arguably a valid parameter to assess the sarcopenic status of a patient. Several studies across a variety of surgical specialities report significant associations between reduced psoas CSA and overall morbidity and mortality, which can be achieved through various methods such as computed tomography (CT) and magnetic resonance imaging (MRI)[8]. Although many studies in the literature describe using CT to measure psoas CSA, MRI is regarded as the most sophisticated imaging technique for characterizing the loss of muscle quality, as it is more sensitive at identifying fibrous connective tissue, adipose tissue, or abnormal oedema[7]. Thus, there is a greater push to employ MRI to evaluate sarcopenia[13].

In this context, a paucity of evidence exists regarding the relationship between sarcopenia and the incidence of LBP, and how radiographic measurements of sarcopenia relate to traditional clinical (performance-based or self-reported) measures. The purpose of this study was to explore such relationships in a sample of older patients attending a low back pain clinic.

Methods

Study Design and Participants

A prospective observational study was conducted over a three-month period from January 1st 2019 - April 1st 2019 in our orthopaedic back pain clinic. Inclusion criteria consisted of patients: (i) aged ≥65 years old; (ii) referred from the primary care setting for chronic (≥6 month's history) lower back pain for which surgical intervention was not warranted; and (iii) had recent (within the preceding 3 months) MRI of the lumbar region of the spine. Exclusion criteria were: (i) history of malignancy; (ii) history of recent (1 month) acute cardiovascular events with relative contraindication for performance-based testing; (iii) movement disorders such as Parkinson's disease.

Anthropometric Data

Height was measured to the nearest 0.1 cm using a stadiometer. Weight was measured to the nearest 0.1 kg using a single pair of electronic scales. Body mass index (BMI; kg/m^2) was calculated.

Self-reported Clinical Assessment Measures for Sarcopenia

SARC-F Questionnaire

The SARC-F questionnaire was developed as a rapid diagnostic test for sarcopenia[13]. There are 5 SARC-F components: Strength, Assistance with walking, Rise from a chair, Climb stairs and Falls (Table 1). The scores range from 0 to 10, with 0 to 2 points for each component. Studies have suggested that a score equal to or greater than 4 is predictive of sarcopenia and poorer outcomes[13].

Oswestry Disability Index (ODI) score

Is a patient completed questionnaire that provides the physician with a patient reported subjective interpretation of disability (secondary to low back pain) with regards to daily function, in terms of a percentage[16]. The ODI index consists of ten statements, each rated from 0-5 (5 being the worst interpretation of disability), for a maximum total score of 50. A result of 0-20% was defined as minimal disability, 21-40%=moderate disability, 41-60%=severe disability, 61-80%=crippled, 81-100%=bed bound[14].

Visual Analogue Scale (VAS) for Pain

Is a common instrument employed in clinical practice that attempts to interpret the degree of symptomatic pain experienced by a patient[15]. It can be presented in a variety of ways. For our study, vertical scales were placed along a horizontal line. Numbers 0 and 10 were noted on the scale. Numbers 1-9 were omitted and simply represented by vertical scales. Patients were asked to place an 'X' on the scale (or number) that best represented the intensity of their pain, with 0 representing minimum pain in terms of severity, and 10 representing maximum pain in terms of intensity[15].

Performance-based Clinical Assessment Measures for Sarcopenia

Hand Grip Strength

Hand grip strength was measured using a digital hand dynamometer (Camry Digital Hand Dynamometer (200

Component	Question	Scoring
Strength	How much difficulty do you have in lifting and carrying 10 pounds?	None = 0 Some = 1 A lot or unable = 2
Assistance in walking	How much difficulty do you have walking across a room?	None = 0 Some = 1 A lot, use aids, or unable = 2
Rise from a chair	How much difficulty do you have transferring from a chair or bed?	None = 0 Some = 1 A lot or unable without help = 2
Climb stairs	How much difficulty do you have climbing a flight of 10 stairs?	None = 0 Some = 1 A lot or unable = 2
Falls	How much difficulty do you have fallen in the past year	None = 0 1-3 falls = 1 4+ = 2

Table 1. SARC-F Screen for Sarcopenia[13].

lbs/90 kgs), Camry Scale (USA), South El Monte, California). Grip strength was measured in a standing position with the forearm away from the body at the level of the thigh. Participants were asked to apply maximum grip strength three times with their dominant hand. There was a 30-second resting time between each application. Grip strength was defined as the maximally measured grip strength of the dominant hand, and presented in kilogram (kg) quantification of force.

Chair Stand Test

Subjects were asked to fold their arms across their chest and to stand up from a sitting position once. If the patient successfully rose from the chair, they were asked to stand up and sit down five times as quickly as possible. The time to perform five chair stands was measured in seconds.

Gait Speed

Gait speed was calculated for each participant using distance in meters and time in seconds. All subjects were instructed to walk at a usual pace and from a static start. A predefined distance of four metres (4 m) was used for the assessment of gait speed in all patients.

Stair Climb/10-Step Test

The stair climb/10-step test was selected to assess subjects' ability to perform a rapid, alternating weight-shift in both the anterior-posterior and lateral directions. While standing, subjects were instructed to climb a set of 10 steps and the time in seconds was recorded. This was performed three times, with the average of the three attempts taken.

MRI Evaluation of Para-Vertebral Muscles

Measurements were taken by two of the authors (one a radiologist), three times each, on two different occasions, and two weeks apart in order to avoid bias. Averages of all measurements were used for analyses. The inter-observer reliability was quantified using the intra-class correlation coefficient, in which values <0.5 are defined as indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability[16].

Adjusted Psoas Cross-Sectional Area (APCSA)

The psoas muscle was chosen due to existing literature regarding it as a good indicator of overall muscle mass, with further studies suggesting analysis of the cross-sectional area of the psoas muscle as a potential radiographic indicator of sarcopenia[17,18]. The cross-sectional area of the psoas muscles was measured using an axial plane magnetic resonance slice of the L4 upper endplate level which was subsequently adjusted for height, providing an adjusted psoas cross-sectional area (APCSA) value[18,19]. The left and right psoas muscles were measured, defined by manually outlining the innermost fascial border surrounding the muscle, and the average taken. ImageJ software (version 1.52q) was used to calculate the APCSA (Figure 1).

Fat Infiltration (FI)

FI was measured on the left side and defined by manually outlining the innermost fascial border of the multifidus and erector spinae muscles. Similarly, axial plane magnetic resonance slices were taken at the level of the L4 upper endplate. The multifidus and erector spinae were chosen based on results of previous studies, reporting a significant association between the FI of both muscles and incidence of LBP[20]. Overall fat infiltration was presented as a summative percentage (%FI) of fat infiltration in the left multifidus and left erector spinae muscles. The quadratus lumborum,

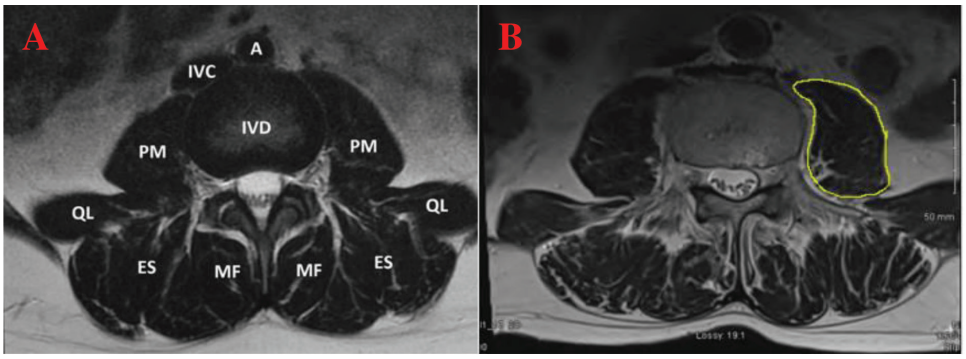

Figure 1. Axial T2 weighted magnetic resonance imaging with ImageJ software (version 1.52q) highlighting demarcation of A) anatomical landmarks, and B) outline of the left psoas muscle fascial borders highlighted in yellow. (A)=aorta. (IVC)=inferior vena cava. (IVD)=intervertebral disc. (PM)=psoas muscle. (QL)=quadratus lumborum. (ES)=erector spinae. (MF)=multifidus.

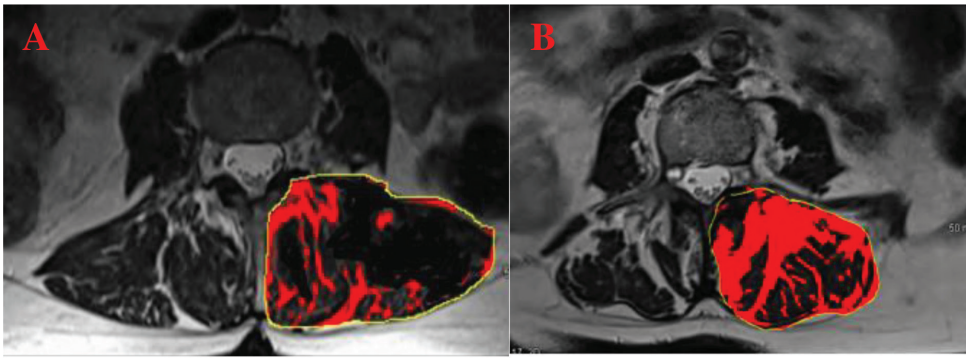

Figure 2. Axial T2 weighted magnetic resonance imaging with ImageJ software (version 1.52q) adjusted threshold highlighting fat infiltration (in red) of A) the left multifidus muscle, and B) the left erector spinae with respective fascial borders highlighted in yellow.

although considered a paraspinal muscle, was not included in this study due to inadequate MRI imaging in a significant proportion of the study sample. The %FI for the multifidus and erector spinae muscles were calculated on ImageJ software (version 1.52q) (Figure 2).

Ethics approval

Institutional board review was granted and approved for the purpose of this study.

Statistical Analysis

Descriptive statistics of continuous variables were reported as mean with standard deviation (SD) and range. Percentages were given for categorical variables. Spearman's correlation analyses were employed to evaluate statistical significance between parameters. A correlation value of <0.3 for two respective parameters is defined as a poor relationship, 0.3-0.6=fair, 0.6-0.8=moderate, >0.8= very strong[21]. All statistical analyses were performed using R (version 3.6.3). A p-value of <0.05 was considered to be statistically significant. All graphs were generated using GraphPad Prism software (version 8.4.1). Images were extracted from the ImageJ software system (version 1.52q).

Results

25 patients were included, with a mean age of 73 years (SD 7.3, range 65-96), and 62% were male. Mean body mass index for the cohort was 28.2 kg/m^2 (SD 5.7, range 19.9-40.9). The summary of the correlation analyses between clinical and radiological measures is presented in Table 2, and further details are presented below.

	Mean SD
Age (years)	73 7.32
Body Mass Index (kg/m²)	28.2 5.66
APCSA (cm²)	331.7 63.7
FI (%)	39.8 11.6

(SD) = standard deviation. (APCSA) = adjusted psoas cross sectional area. (%FI) = percentage fat infiltration

Table 2. Demographic and Radiographic Characteristics.

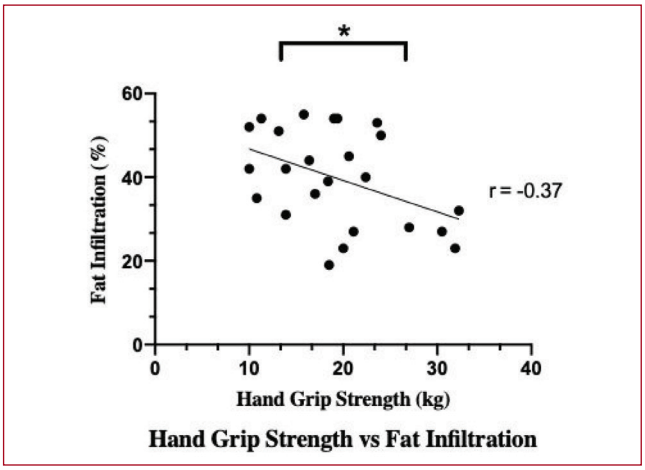

Figure 3. Spearman correlation analysis for respective hand grip strength and fat infiltrate parameter values for each patient. (*)= p<0.05.

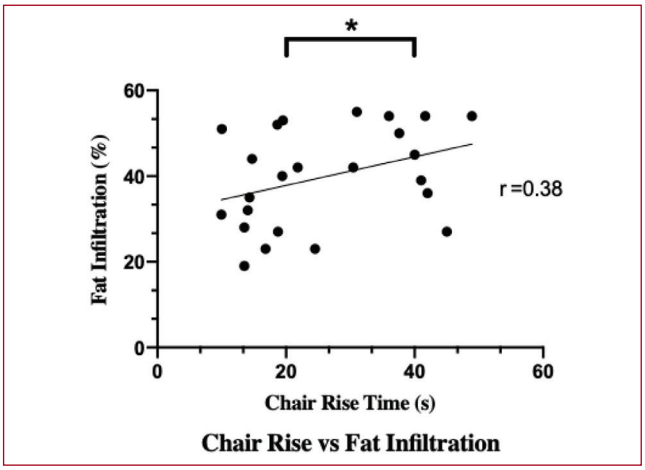

Figure 4. Spearman correlation analysis for respective chair rise and fat infiltrate parameter values for each patient. (*)= p<0.05. (s)= seconds.

Hand Grip Strength

With regards to %FI, a statistically significant relationship in the expected direction was evident (r=-0.37; p=0.03) (Figure 3). However, there was no significant relationship with APCSA (r=0.34; p=0.05).

Chair Rise Time

Chair rise time shared a significant relationship with the degree of FI seen on imaging (r=0.38; p=0.03), with increased fat infiltration corresponding to increased time taken to rise from a chair (Figure 4). However, no significant relationship was evident between chair rise time and APCSA (r=0.10; p=0.32).

Stair Climb/10-Step Test

With regards to the stair climb test, a significant relationship was demonstrated with %FI (r=0.64; p<0.01), indicating that patients with a larger degree of fat infiltration took longer to perform the task (Figure 5). Contrarily, no significant relationship was evident between stair climb and APCSA (r=-0.17; p=0.22).

Gait Speed

No statistically significant association existed for gait speed and radiological measures of %FI (r=0.32; p=0.06) or APCSA (r=0.17; p=0.22).

SARC-F Questionnaire

Similarly to gait speed, the SARC-F questionnaire shared no significant relationship with either %FI (r=0.33; p=0.06) or APCSA (r=0.10; p=0.32) on Spearman's analysis.

Visual Analogue Scale Score

There was a significant association between the degree of fat infiltration on imaging, and symptomatic reporting of pain via the visual analogue scale (VAS) (r=0.40; p=0.02), conveying that those with a higher %FI were more likely to report a higher VAS score (Figure 6). No such similar association was seen when APCSA and VAS were compared together (r=-0.14; p=0.23).

Oswestry Disability Index

Although a relationship was identified with VAS score and % FI, this was not evident with Oswestry Disability Index (ODI) scores collated for each patient (r=0.24; p=0.13). Furthermore, ODI and APCSA proved statistically insignificant on analysis (r=-0.04; p=0.42). A summary of results are outlined in Table 3.

Adjusted Psoas Cross-Sectional Area vs. Degree of Fat Infiltration

The intra-class correlation coefficient for %FI measurements was 0.91 and that of APCSA was 0.96. Mean %FI was 39.8% for the cohort (SD 11.6, range from 19 to 55). Eight out of 25 patients (32%) had %FI of ≥50%. Mean APCSA was 331.7 cm² (SD 63.7 and a range

Clinical Measure	% FI	APCSA
Hand grip strength	**Significant (r= -0.37;p=0.03)**	Non-significant (r=0.34; p=0.05)
Chair rise	**Significant (r=0.38; p=0.03)**	Non-significant (r=0.10; p=0.32)
Stair Climb	**Significant (r=0.64; p<0.01)**	Non-significant (r= -0.17; p=0.22)
Gait speed	Non-significant (r=0.32; p=0.06)	Non-significant (r=0.17; p=0.22)
SARC-F questionnaire	Non-significant (r=0.33; p=0.06)	Non-significant (r=0.10; p=0.32)
Visual Analogue Score	**Significant (r=0.40; p=0.02)**	Non-significant (r= -0.14; p=0.32)
Oswestry Disability Index	Non-significant (r=0.24; p=0.13)	Non-significant (r= -.04; p=0.42)

(% FI) = percentage of fat infiltration. (APCSA) = adjusted psoas cross-sectional area.

Table 3. Summary of Spearman Correlation Analyses.

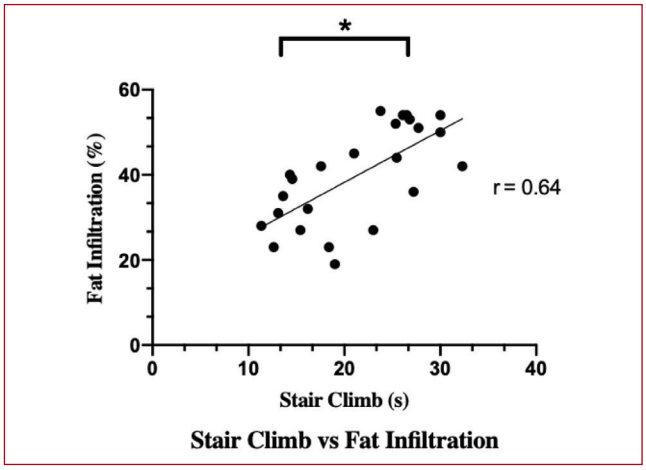

Figure 5. Spearman correlation analysis for respective stair climb and fat infiltrate parameter values for each patient. (*)= p<0.05. (s)= seconds.

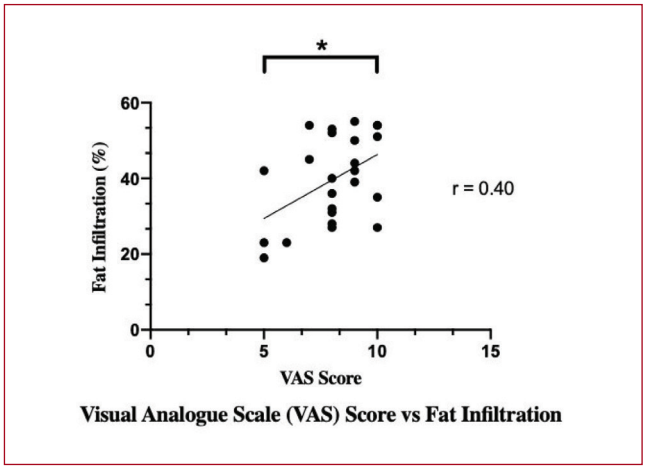

Figure 6. Spearman correlation analysis for respective visual analogue scale score and fat infiltrate parameter values for each patient. (*)= p<0.05.

from 263.5 to 483.7). Between these two measures, a statistically significant inverse relationship was evident (r=-0.40; p=0.02), depicting that those with a higher degree of fat infiltration had significantly less appreciable cross-sectional area of psoas lean muscle mass (Figure 7).

Discussion

In this study, we evaluated the relationship between clinical measures and radiological indicators of sarcopenia in a sample of older chronic lower back pain outpatients. Whilst APCSA showed no significant associations with clinical measures, %FI was significantly associated with self-reported pain scores, hand grip strength, and chair rise and stair climb times.

Our results indicate more significant relationships between %FI and performance-based measures, with pain being the only self-reported measure in significant

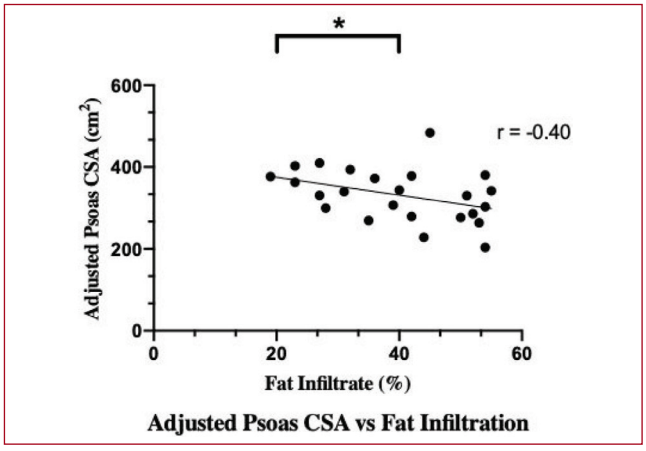

Figure 7. Spearman correlation analysis for respective adjusted psoas cross-sectional area and fat infiltrate parameter values for each patient. (*)= p<0.05. (cm)= centimetre.

association. Based on the correlation found with %FI, it is possible that higher levels of chronic pain represent a more advance state of disability and sedentary behaviour in the older adult, which may be captured to a lesser extent by SARC-F and ODI. On the other hand, preferred gait speed was the least 'extenuating' performance-based test in our battery, with hand grip strength, chair rise and stair climb requiring more peak muscle strength. Also as suggested by their significant association with %FI, our results support previously postulated mechanistic links between increases in muscle fat infiltration and muscle weakness or dynapenia[22]. For example, in a study of 72 patients by Teichtahl et al., a high %FI in the multifidus was associated with high-intensity pain, disability and modic changes, while CSA of neither the multifidus nor erector spinae was associated with reports of pain and disability[20].

Nevertheless, our results aid identification of a potential link between sarcopenia and reports of LBP. As literature depicts, psoas CSA is regarded as a good indicator of sarcopenia, and %FI in the multifidus and erector spinae have shown strong association with reports of LBP[17,20]. Thus, a statistically significant relationship evident on Spearman's correlation analysis (r=-0.40; p=0.02) between APCSA and %FI substantiates a hypothesis that sarcopenia may influence the prevalence of LBP in older cohorts. Furthermore, % FI shared statistically significant associations with traditional clinical measures of evaluating sarcopenia, such as grip strength (p=0.03), chair rise (p=0.03) and stair climb (p<0.01) (Table 3).

Accurate and reliable radiographic evaluation of sarcopenic status could allow future studies to extrapolate or investigate potential radiographic cut-off values for clinical and sub-clinical sarcopenia. Even though the efficacy of clinical performances measures are known and used extensively, they are limited in their ability to interpret sarcopenia clinically. Early radiographic identification of sub-clinical sarcopenia would allow physicians to monitor with serial imaging, or intervene earlier with strategies aimed at either preventing the progression, or reversing sarcopenia. Results of several preliminary early intervention studies report positive preliminary findings regarding the ability to potentially prevent sarcopenia through pharmacological and non-pharmacological methods, including pain control and multimodal rehabilitation approaches[23].

Additionally. quantitative values for diagnostic sarcopenia on imaging negate potential subjective bias in interpretation of clinical measures by the physician or examiner. Nolan et al.[8] report in a study of 130 participants, that overall mean and maximum grip strength, in addition to individual measurements for dominant and non-dominant hands, varied dependent on the assessor, with a tendency to note a higher value when two grip strength measures were taken for the non-dominant hand in the same assessment. Although the discrepancies in values appeared negligible, it has also been reported that there are variations in appreciable minimum clinically important difference (MCID) with traditional clinical assessments, dependent on background medical history, highlighting the need for diagnostic measurements with minimal variations among physicians or graders[8,24]. Thus, the renowned reliability of MRI represents a significant strength, evident in our study for noted intraclass coefficient for both ASPCA (0.96) and %FI (0.91).

There are certain limitations to this study. It is limited by a small cohort number, even though the study is prospective in design. This was influenced by a predefined parameter that MRI scans must be within the preceding 3 months. Additionally, while statistically significant relationships existed between several parameters, strength of relationships were moderate at best. Some of the non-significant relationships could have become so with larger sample sizes (notably APCSA vs. hand grip strength, %FI vs. SARC-F, and %FI vs. gait speed, all of which were close to significance). Whilst several studies report psoas CSA as a good marker for the sarcopenic status of patients, certain academics question the efficacy of utilizing one singular muscle as a sentinel marker for evaluating loss of overall muscle mass[25]. Unfortunately, the quadratus lumborum could not be assessed due to adequate imaging, and serves another limitation. Furthermore, there are attempts to derive novel methods of evaluating 'central sarcopenia' in spine patients[26]. To date, these new methods are neither widely validated nor employed. However, future studies may wish to perform a sensitivity analysis to elucidate the most efficacious method of evaluating sarcopenia in spine patients. Nevertheless, our results add knowledge to the growing body of sarcopenia research since its formal definition as a pathological state in 2016, regarding an association between sarcopenia and chronic LBP. Thus, should the belief that sarcopenia is preventable and/or reversible hold true, we can potentially reduce the prevalence of one of the largest presenting complaints to physicians worldwide through early identification and intervention.

Conclusion

The results of our study demonstrate a statistically significant relationship between APCSA and %FI in the multifidus and erector spinae muscles. However, only %FI showed a correlation to established clinical measurements. Thus, %FI may be a supplemental indicator of the sarcopenic status of patients presenting with chronic low back pain and ultimately play a greater role in the assessment of low back pain and sarcopenia than area-based measurements alone.

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