Research Article

Relative Validity of Upper Arm Anthropometry as a Field Method for Estimating Skeletal Muscle Mass in Adults with Peripheral Arterial Disease

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Abstract

Maintenance of skeletal muscle mass (SMM) is integral to better health outcomes for adults with peripheral arterial disease (PAD). For those with intermittent claudication (IC), muscle mass has a role in maximising pain free walking distance, in critical limb ischemia (CLI) there is risk of muscle atrophy secondary to disuse and increased protein requirements. The purpose of this study was to determine whether upper arm anthropometry would be an acceptable field method for estimating SMM in adults with PAD. Adults with IC (n=27) or CLI (n=25) were recruited from the Southern Adelaide Health Service. SMM was derived from dual energy x-ray absorptiometry (DEXA), the reference technique, according to an established equation. SMM was derived from corrected arm muscle area (CAMA), the field technique, according to an established equation. Correlation, t-tests and Bland-Altman analysis were performed to determine level of agreement between techniques. Mean (SD) age was 69.9 (11.8) years, n=36/52 male and body mass index was 28.5 (6.3) kg/m². SMM from DEXA and CAMA were highly correlated (r=0.9, P<0.001) but significantly different, mean (SD) SMM from DEXA and CAMA were 23.7 (6.3) kg and 20.3 (5.7) kg respectively, P<0.001. Mean bias and limits of agreement for SMM between DEXA and CAMA were 3.5 (-3.1, 10.1) kg. Clinicians should be cautious in using CAMA to estimate SMM as the difference is clinically meaningful. Further work is required to determine whether a predictive equation using CAMA alongside other field measures of SMM can achieve a better level of agreement with DEXA.

Keywords
- Skeletal muscle mass
- Peripheral arterial disease
- Body composition
- Nutrition assessment

INTRODUCTION

Body composition, specifically fat and skeletal muscle mass (SMM), has been demonstrated to be predictive of health outcomes across the lifecycle. High levels of fat mass have consistently been demonstrated to increase risk of vascular disease in children [1] and adults [2]. Low SMM, particularly in advanced age, has consistently been demonstrated to increase risk of falls, fragility fracture, infection and poor wound healing [3-6]. Assessment of body composition is therefore an important component of nutritional assessment, particularly in patient groups where alterations in body composition occur and poor nutritional health can be masked by higher total body weight as is the case with sarcopenic obesity.

It has been proposed that adults with peripheral arterial disease (PAD) have alterations in body composition, with higher fat mass common in early stages of disease progression [2] and a decline in SMM or atrophy of skeletal muscle as the disease progresses [7]. Although evidence to support this assertion is scant, it is likely that muscle atrophy in these patients occurs as a result of disuse precipitated by ischaemic pain in claudication and increased protein and energy requirements associated with ischaemic ulcers and vascular intervention [8,9]. Significantly, such a decline in SMM is probably greater than the expected age related decline in SMM. Accurate and feasible methods for measurement of SMM in this patient group are therefore justified and required as this facilitates a more comprehensive nutritional assessment of this nutritionally vulnerable group of patients with the potential to improve both short and long term health outcomes.

Assessing SMM accurately in the clinical setting is challenging in the absence of an acceptable field method for measuring or estimating SMM in adults with PAD. Dual-energy X-ray Absorptiometry (DEXA) is globally accepted as an acceptable method for measuring fat and fat free mass however use in everyday clinical practice is limited. Lack of availability and cost of equipment, lack of portability and the inability of some patients to assume the correct position for measurement all limit the feasibility of DEXA [10]. There is hence a need for a more practical method of assessing body composition, particularly SMM, which is valid and able to be used in the clinical setting as part of nutritional assessment.

Corrected arm muscle area (CAMA) is an anthropometric index derived from non-invasive measures of the mid-upper arm circumference (MUAC) and the triceps skinfold (TSF) using established equations [11]. Corrected arm muscle area has been shown to be independently predictive of poor health outcomes in older adults and various patient groups including vascular and rehabilitation [12-15]. In these studies, CAMA has been shown to be a better indicator than BMI. CAMA can be converted to total SMM using an additional set of predictive equations [12]. These measures are considered more feasible in the clinical setting compared to the alternative of bioelectrical impedance given the cost of the equipment and consumables, the requirement for stable hydration, fasting and positioning of the electrodes at the wrist and ankle [16,17].

The aim of the current study is to compare SMM derived from CAMA with SMM derived from DEXA in a heterogeneous group of vascular patients to determine if it is a valid field technique for assessing SMM in this patient group.

**MATERIALS AND METHODS**

Adults aged ≥ 18 years with intermittent claudication (n=27) or critical limb ischemia (n=25) were recruited from the Southern Adelaide Health Service Department of Vascular Surgery Claudication Clinic or from the inpatient service at Flinders Medical Centre respectively between July 2011 and May 2012. Data collected from two vascular surgery studies conveniently formed the basis for the analyses presented in this study. These data were collected according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Southern Adelaide Human Research and Ethics Committee. Written informed consent was obtained from all subjects.

Participants with intermittent claudication were concurrently enrolled in a randomised controlled trial to evaluate the effects of two structured 12 week supervised exercise programs: treadmill alone or treadmill combined with resistance training. All participants had clinical and radiological evidence of infrapopliteal PAD manifesting as intermittent claudication and no underlying co-morbidities that would prohibit their participation in an exercise program. For the purpose of the current study, only the baseline measurements of body composition were used in the analyses. Participants with critical limb ischemia were concurrently enrolled in a study evaluating the impact of endovascular intervention on resting energy expenditure. All participants had clinical and radiological evidence of infrainguinal PAD manifesting as intermittent claudication or critical limb ischaemia separately and combined. To assess agreement between both methods of estimating SMM mean bias and 95% limits of agreement (LOA) were calculated and illustrated consistent with recommendations of Bland and Altman [20].

**RESULTS**

Table 1 presents the descriptive characteristics of the 52 participants, 27 with intermittent claudication and 25 with critical limb ischemia and mean (SD) age of 69.9 (11.8) years. The mean age of those with intermittent claudication (69.0, SD 11.0) was not significantly different from those with critical limb ischaemia (70.8, SD 12.6), P=0.593. There were statistically significant differences between males and females for mean weight and height with men being significantly heavier (P=0.002) and taller (P<0.001). Similarly, SMM for males was statistically significantly greater than females when estimated by both DEXA (P=0.005) and CAMA (P<0.001). Mean (SD) SMM estimated from DEXA was 24.2 (6.3) kg for participants with intermittent claudication versus 23.1 (6.4) kg for participants with critical limb ischemia, P=0.534. Mean (SD) SMM estimated from CAMA was 20.7 (5.7) kg for participants with intermittent claudication versus 19.8 (5.7) kg for participants with critical limb ischemia, P=0.585. Independently, those with intermittent claudication (SMM estimated from CAMA: mean 20.7 SD 5.7 kg versus SMM estimated from DEXA: mean 24.2 SD 6.3 kg, P<0.001) and those with critical limb ischaemia (SMM estimated from CAMA: mean 19.8 SD 5.7 kg versus SMM estimated from DEXA: mean 23.1 SD 6.4 kg, P<0.001) were significantly different for SMM when measured by both methods.

**Table 1: Descriptive characteristics of the 52 participants.**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD) Age, years</td>
<td>68.6 (10.8)</td>
<td>72.7 (13.6)</td>
<td>69.9 (11.8)</td>
<td>0.255</td>
</tr>
<tr>
<td>Rutherford’s Classification</td>
<td>18 (9)</td>
<td>9 (7)</td>
<td>27 (25)</td>
<td>0.677</td>
</tr>
<tr>
<td>Mean (SD) Weight, kg</td>
<td>86.2 (18.7)</td>
<td>67.4 (19.3)</td>
<td>80.4 (20.6)</td>
<td>0.002</td>
</tr>
<tr>
<td>Mean (SD) Height, cm</td>
<td>173.0 (6.3)</td>
<td>156.9 (4.3)</td>
<td>168.2 (9.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean (SD) BMI, kg/m²</td>
<td>28.8 (6.0)</td>
<td>27.6 (7.3)</td>
<td>28.5 (6.3)</td>
<td>0.522</td>
</tr>
<tr>
<td>Mean (SD) SMMDEXA, kg</td>
<td>27.7 (4.8)</td>
<td>16.9 (3.3)</td>
<td>23.7 (6.3)</td>
<td>0.005</td>
</tr>
<tr>
<td>Mean (SD) SMMCAMA, kg</td>
<td>22.3 (5.1)</td>
<td>15.4 (3.8)</td>
<td>20.3 (6.0)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Combining all participants (intermittent claudication and critical limb ischemia), a strong correlation was evident between SMM estimated from DEXA and SMM estimated from CAMA (r=0.854 and P<0.001), however according to a paired-samples t-test there was a statistically significant difference between mean (SD) SMM estimated from DEXA and SMM estimated from CAMA, 23.8 (6.7) kg versus 20.3 (5.7), P<0.001. Figure 1 illustrates mean bias and LOA for SMM estimated from DEXA and SMM estimated from CAMA. Mean bias was 3.5 (3.3) kg and LOA -3.1, 10.1 kg.

**DISCUSSION**

This is the first study to investigate the validity of a field method for estimating skeletal muscle mass in patients with PAD. A strong correlation was observed between SMM derived from DEXA and CAMA, however there was a statistically significant and clinically meaningful difference between the mean SMM derived from CAMA compared to DEXA.

The magnitude of the bias between the mean SMM derived from CAMA compared to DEXA was 3.5 (3.3) kg, so at the individual level, there is the potential to underestimate SMM by 6.6kg. In the current study the mean SMM was 24.2 (6.3) kg for participants with intermittent claudication and 23.1 (6.4) kg for participants with critical limb ischemia. An error of up to 6.6kg in SMM would result in a 30% under or over-estimate in SMM at an individual level which could lead to significant investment of resources for maintenance or gain of SMM that may not be warranted.

While it is not surprising that the magnitude of the limits of agreement would be too wide to warrant application at an individual level, many similar studies in other patient groups do suggest that there is still potential for the use of the field method at a group level or for the purpose of research. The findings of the present study however would not concur with these recommendations as the mean bias equated to the potential for underestimating SMM by 3.5kg. Underestimation can lead to over identification of muscle depletion leading to overutilization of health resources and potentially excessive nutrition support.

Given the evidence to suggest that there is a difference in body composition with the progression of PAD, with a reduction in SMM as the disease progresses [21] it might be possible that the use of CAMA performs differently according to the stage of disease. In the present study however, no statistically significant difference was found when comparing the SMM of the claudicants and the CLI participants despite a trend for claudicants having a higher SMM according to both DEXA and CAMA compared to those participants with CLI.

The inability to reach statistical significance in SMM according to stage of disease in the present study may be due to the modest sample size. While the sample size is not dissimilar to comparable studies [16] it is possible that with a larger study sample a lower SMM would be observed with increasing severity of PAD. An increase in sample size would also likely lead to a narrowing of the limits of agreement between SMM estimated by CAMA and DEXA, although it is not possible to comment on whether the magnitude of this change would be sufficient to support the use of CAMA as a field method in this population. Whether the magnitude of the difference between the two methods is meaningful in terms of the impact on clinical practice is challenging to define given the lack of established cut-offs for desirable SMM in this patient group. Ideally the level of misclassification of patients according to established cut-offs with demonstrated high levels of sensitivity and specificity and predictive value would guide interpretation. These values however are currently unavailable.

**CONCLUSIONS**

It must be acknowledged that given the limitation of sample size for this study that these findings are preliminary and further work in this area is warranted to confirm these findings. Further work would also be valuable to include other stages of PAD including minor and major tissue loss, where nutritional status may be further compromised in comparison to claudicants and CLI patients. This is the first study however to test the validity of a field method for estimating SMM in the PAD patient group and provides important data to inform clinicians of the limitations of using SMM from CAMA as an estimate of SMM. It is possible that with further work CAMA might be able to be used as part of an algorithm to predict SMM with greater accuracy but for now it would be prudent for clinicians to be cautious of this field technique. Ultimately, given the health benefits associated with preservation of SMM, the addition of such methods to the armamentarium of dietitians would enable more comprehensive nutritional assessment of these vulnerable patients with the potential to improve health outcomes. Further research could also be undertaken using alternative field methods such as bioimpedance methods however the cost of equipment and consumables for these techniques would need to be considered. Furthermore there may be an issue with validity given the sensitivity of these devices to hydration status.

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JI Spark was involved in the project design and writing of this manuscript.

M Miller was involved in the design and implementation of the project, data analysis and the writing of this manuscript.

REFERENCES


