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Original Article

Relation Between Ultrasonographic Measurements of the Biceps Brachii and Total Muscle Mass in Older Hospitalized Persons: A Pilot Study

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Abstract

Objectives: To assess the link between ultrasonographic measurements of the biceps brachii and total muscle mass measured by bio-impedancemetry in hospitalized older patients. **Methods**: A prospective observational study was conducted. The study included patients older than 65 years admitted in internal medicine, acute geriatrics, orthogeriatrics and rehabilitation departments. All measurements, ultrasonographic measurements and muscle mass and function by bio-impedancemetry and dynamometry, were taken within the first 48 hours of admission. **Results**: In total 19 patients were included, the mean age was 85.4 ± 3.9 years and 7 (36.8%) were females. Very strong direct correlations were obtained in the entire cohort in both biceps brachii cross-sectional area and muscle thickness with skeletal muscle mass displayed in kilograms. **Conclusion**: Biceps brachii looks like a very good muscle measuring tool: easy, comfortable, fast, good correlated with total body muscle mass. This muscle could effectively be used for the assessment of muscle mass in the diagnosis of sarcopenia since it reflects muscle mass precisely, however more studies are needed to provide reference values in all age cohorts.

Keywords: Biceps brachii, Older people, Sarcopenia, Ultrasound

Introduction

Sarcopenia is a geriatric syndrome defined as a progressive and generalized skeletal muscle disorder[1], associated with an increased likelihood of adverse outcomes including falls, fractures, physical disability, and mortality[1-3]. The prevalence of sarcopenia is strongly heterogenic due to the difference in assessment methods and cut-off points used. In acute hospital-care it is estimated to be 10% while in community-dwelling older people this prevalence varies between 1-29%[4].

Hospitalized patients are at an increased risk for sarcopenia due to several reasons, especially in older people[5]. During an episode of acute illness and hospitalization, there are not only increased periods of bed rest and a very high chance of malnutrition[6], this period is accentuated by inflammatory processes[7], oxidative stress[8] and hypercortisolemia[9]. All these have a negative effect on muscle mass. Thus sarcopenia, seen as chronic muscle failure, can also develop an acute component in hospitalized situations[9,10].

Diagnosing sarcopenia requires the proper evaluation of muscle quantity and quality[11]. Dual-energy X-ray absorptiometry (DXA) and bio-impedancemetry (BIA) have

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Inclusion criteria
• Age ≥ 65 years
• Hospitalized in internal medicine, acute geriatrics, orthogeriatrics and rehabilitation wards
Exclusion criteria
• Test positive for COVID-19 o suspect it
• Patient on dialysis
• Paresis of the lower limbs or hemiparesis
• Thyroid pathology under treatment
• Fluid and electrolyte imbalance
• Contraindications for BIA
• Diseases that may have caused changes in muscle mass
• Chronic oral corticosteroids or anti-androgenic treatment

Table 1. Inclusion and exclusion criteria summary.

been proved efficient to measure muscle quantity, but they are not suitable to evaluate muscle quality[11]. Computed tomography (CT) and magnetic resonance imaging (MRI) provide both qualitative and quantitative data, however these techniques are invasive and expensive, have no cut-off points and therefore are not feasible to use in clinical practice[12]. Ultrasound (US) has the advantage of being able to assess both muscle quantity and quality and has proven to be an accurate, high repeatability and reliable technique with good validity, as compared to DXA, MRI and CT, to measure muscle mass in different populations[12]. Furthermore, it is an affordable, non-invasive method that is portable and available bedside so it is suitable for use on an acute ward. Muscle thickness (MT) and cross-sectional area (CSA) are parameters that have been used to estimate muscle quantity[13] while pennation angle (PA), fiber length (FL), and elastography (SWE) have been used to assess muscle quality[14]. Despite its still very limited use in clinical practice due to the absence of cut-off values, attempts have been made to standardize US muscle mass measurements by the SARCUS project[15], and published research have showed that a brief training course achieves improvement in musculoskeletal US image interpretation skills and confidence[16].

In the last decade, US has become the most important emerging technique in muscle mass assessment. Recently studies have published predictive equations based on US values to assess appendicular muscle mass[14] or to diagnose sarcopenia, as the so-called Ultrasound Sarcopenia Index (USI)[17]. Rectus femoris and vastus lateralis are the most studied muscles in research and a relationship between ultrasonographic measurements of these muscles with low muscle mass, low muscle strength and even sarcopenia in older persons has been shown[18-21]. However, for screening purposes of large groups of persons, either patients or healthy subjects, measuring the rectus femoris of vastus lateralis can pose some practical issues and some studies have been done in order to look into measurements of the upper limb[22-24]. Another viable candidate for a muscle that require less patient collaboration and in which the anatomical point determination is easier is the biceps brachii (BB). To confirm these candidates, correlations with total body muscle mass or certain outcomes need to be studied.

Therefore, the aim of this pilot study is to assess the link between ultrasonographic measurements (MT, CSA) of the BB and total muscle mass as measured by BIA in hospitalized older patients.

Material and methods

Study design

A prospective observational study was conducted. A control group was not included in the present pilot study. However, researchers from the same research group previously carried out a study with younger healthy subjects in which the relationship between BB ultrasound measurements and muscle mass was studied[24].

Inclusion criteria

Included wards for admission were: internal medicine, acute geriatrics, orthogeriatrics and rehabilitation. Age limit was set on 65 years and older.

During the tests, all safety measures regarding the COVID-19 pandemic were taken into account. This included the wearing of protective face masks, gloves and face shields during ultrasound examination and bio-electrical impedance analysis, decontamination of equipment in between the subjects.

Exclusion criteria

First of all, subjects with symptoms suggestive of COVID-19 or a positive test within the previous 14 days were excluded.

Patients on dialysis were excluded because of possible metabolic features. Individuals with paresis of the lower limbs or hemiparesis due to a stroke were excluded because of neurological involvement that could influence the results. Hypo-or hyperthyroid patients with non-stable or recompensated thyroid disease under medication were excluded because of the role of thyroid hormones in muscle homeostasis. Pitting oedema of the legs or severely dehydrated patients were excluded because fluid shifts could influence the ultrasound measurement results.

Patients with contraindications for BIA, such as implanted cardiac devices (cardiac pacemaker, implantable cardioverter-defibrillator), metal implants such as joint prostheses or osteosynthetic material were excluded. Because of possible previous changes in muscle mass, architecture and function, patients with systemic connective tissue disorders, myositis, calcification and ossification of muscle, systemic atrophies primarily affecting the central nervous system and demyelinating diseases of the central nervous system were also excluded. Last, patients using chronic oral corticosteroids or anti-androgenic medication were excluded. Table 1 shows a summary of the inclusion and exclusion criteria.

Measurements

All measurements were taken within the first 48 hours of admission.

Subject characteristics

Date of birth, age (years), gender, height (cm) and weight (kg) were registered. If the patient was bedridden, weight was measured through either weight chairs or weight measuring lifts, and height was estimated using the ulna length or knee heigh[25]. Date of admission was noted. The main reason of hospital admission and the comorbidities following the Charlson Comorbidity Index were registered.

Ultrasonographic measurements

In order to obtain reliable and consistent measurements, all ultrasonography were done by an ultrasonographist that is trained to perform the measurements proposed. An Aplio 300 apparatus (Canon Medical Systems, Otawara, Japan) was used with a linear transducer of 5 cm width with a beam frequency of 12 MHz.

The ultrasound was performed in a supine position, with the arm in a neutral and resting position (forearm between pronation and supination), and hips in neutral position and knees fully extended after a minimal time period of 5 minutes of absolute rest. In the Figure 1 can be seen a demonstration of patients positioning.

Figure 1. Demonstration of the measurement location at 75% of the distance between the acromioclavicular joint and the elbow crease (distally).

The BB muscle of the dominant arm was examined at the 75% distal point from the acromion of the distance between the acromioclavicular joint and the elbow crease according to the SARCUS protocol from Perkisas et al[15]. Muscle thickness, cross-sectional area and elastography were measured 3 times, after which the mean value was noted. Figure 2 demonstrates the ultrasonographic measurement of MT and CSA in a study subject.

Muscle mass

Muscle mass was evaluated using Bioelectrical Impedance Analysis[26]. The model used was the INBODY S10 multifrequency segmental device, specific for hospitalized patients that is used in the supine position.

Muscle strength

Muscle strength was measured through hand grip strength using a Jamar dynamometer, using the Southampton protocol[27]. Measurement was done directly after the ultrasonographic assessment.

Questionnaires

The SARC-F[28] and FRAIL-scale[29] were completed as routine screening questionnaires for sarcopenia and frailty, respectively and the patient nutritional state was registered through the Mini-Nutritional Assessment - Short Form (MNA-SF)[30].

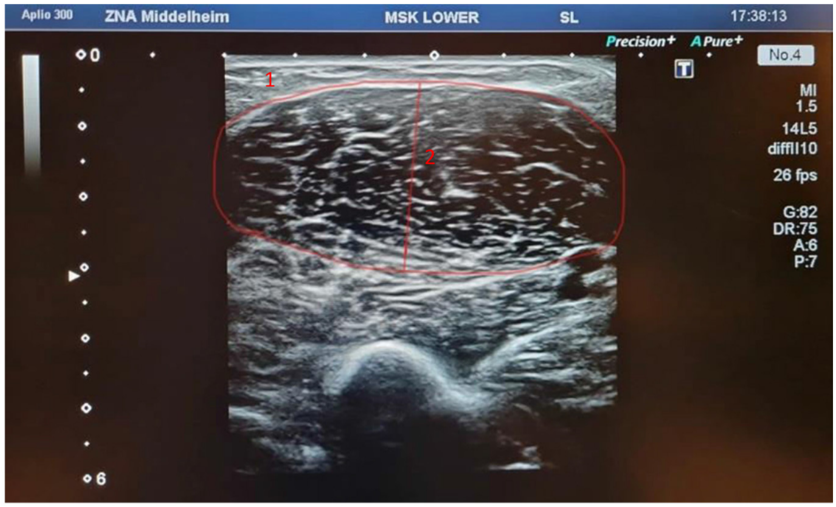

Figure 2. Ultrasound image where 1 represents the cross-sectional area and 2 the muscle thickness.

	Total (n=19)	Males (n=12)	Females (n=7)
Age (years)	85.4 ± 3.9	84.1 ± 3.3	87.6 ± 4.2
Body mass index (kg/m^2)	24.6 ± 3.8	25.4 ± 3.8	23.2 ± 3.6
CCI (points)	8.1 ± 2.3	8.5 ± 2.2	7.4 ± 2.4
MNA-SF (points)	8.4 ± 3.0	8.0 ± 3.5	9.0 ± 2.1
SARC-F (points)	5.1 ± 2.1	4.8 ± 2.3	5.6 ± 1.9
FRAIL (points)	2.8 ± 1.2	2.7 ± 1.2	3.0 ± 1.2
Handgrip (kg)	19.5 ± 9.8	23.3 ± 10.1	12.9 ± 4.4*
Skeletal muscle mass (kg)	26.4 ± 6.3	30.1 ± 4.8	20.1 ± 2.1*
Skeletal muscle mass (%)	37.9 ± 4.5	39.5 ±4.1	35.1 ± 4.0*
Fat mass (kg)	20.2 ± 7.1	20.9 ± 7.4	19.1 ± 6.8
Fat mass (%)	28.9 ± 7.5	26.8 ± 6.8	32.4 ± 7.9
Biceps brachii CSA (cm^2)	6.3 ± 2.4	7.5 ± 2.0	4.1 ± 0.8*
Biceps brachii MT (cm)	1.8 ± 0.4	2.0 ± 0.3	1.4 ± 0.2*

*Data are shown as average ± standard deviation. *p< 0,05 between women and men. Effect size is shown for statistically significant differences. CCI = Charlson comorbidity index; MNA-SF = mini-nutritional assessment – short form; CSA = cross-sectional area; MT = muscle thickness.*

Table 2. Characteristics of the patients included in the study.

Statistical analysis

As a pilot study, the effect size was not calculated as there are no earlier studies regarding biceps-related muscle measurements. Statistical analysis will be done by using SPSS Statistics version 27.

Descriptive analyses will be used for determining the clinical characteristics and a Shapiro Wilk test will be used to verify the normal distribution of the different variables. The analysis by gender was performed using the parametric Student's t-test and homogeneity of the variances was tested with the Levene test.

Pearson's chi-squared test will be used to assess correlations between ultrasonographic measurements and total body muscle mass through BIA. The magnitude of

	Skeletal muscle mass (kg)		
	Total (n=19)	Males (n=12)	Females (n=7)
Biceps brachii CSA (cm^2)	r = 0.906**	0.787**	0.861*
Biceps brachii MT (cm)	r = 0.858**	0.701*	0.535
*p<0.05, **p<0.01			

Table 3. Significant bivariate correlations between skeletal muscle mass (kg) and biceps brachii ultrasound parameters.

the correlation was evaluated using the r absolute value and interpreted using the following conventions: very weak correlation when r < 0.2, weak correlation when r < 0.4, moderate correlation when r < 0.6, strong correlation when r < 0.8 and very strong correlation when r ≤ 1.0.

P-values of ≤0.05 will be considered statistically significant.

Results

In total 19 patients were included, 12 males and 7 females. The clinical, anthropometric, body composition and functionality, biochemical, and OS variables, both in the complete cohort and by gender, are described in Table 2.

The studied population has a mean age of 85 years and a BMI corresponding to normal weight. According to the average score of the screenings carried out, it is a population at risk of malnutrition, with sarcopenia and with pre-frailty. When observing these values by gender, women have a better nutritional status but a higher score in the sarcopenia and frailty screenings.

Handgrip strength is below the cutoff points proposed by EWGSOP2 in both genders[1]. For muscle strength, skeletal muscle mass (measured in kg and as a percentage), CSA and MT of the BB, statistically significant differences were obtained between genders with higher values in males than in females in all cases. The effect size is large in all the differences obtained except in the two skeletal muscle mass parameters, in which the effect size obtained is medium.

When studying the correlations between skeletal muscle mass with BB ultrasound parameters, the significant results shown in Table 3 are obtained. Table 3 shows the significant bivariate correlations when skeletal muscle mass is displayed in kilograms. Very strong direct correlations are obtained in the entire cohort in both biceps brachii CSA and MT. When studying women and men separately, strong direct correlations are obtained in both parameters in the case of men and in CSA in the case of women.

Discussion

This study is the first one to assess the link between ultrasonographic measurements (MT, CSA) of BB and total muscle mass as measured by BIA in hospitalized older patients. Biceps brachii was used as an easier and more time-efficient alternative for the more commonly used rectus femoris and vastus lateralis[31-34] and the results obtained are promising. However, it must be taken into account that this is a pilot study, and the results must be confirmed in larger samples. These results inform us that there is a link between these parameters and also allow us to know the mean and the variability of them in the studied population. Based on this information, the sample size for future studies can be calculated.

As shown in Table 3, the skeletal muscle mass of the patients studied correlates directly and strongly with both BB muscle thickness and cross-sectional area. This is also seen in younger community-dwelling persons[24]. The results are maintained when studying men and women separately, except for muscle thickness, which ceases to correlate with muscle mass in the hospitalized women studied. So cross-sectional area seems to be the most accurate parameter for assessing muscle mass at the level of BB within this small group of women.

These data indicate that, in the same way that has been seen with rectus femoris and vastus intermedius, BB could effectively be used as a muscle for the assessment of muscle mass in the diagnosis of sarcopenia since it reflects muscle mass precisely. A recent systematic review that evaluated the accuracy of ultrasound as a diagnostic technique for sarcopenia found that lower extremity muscles are widely used more by authors for the assessment of sarcopenia than the upper extremity or trunk muscles. The review included 15 studies and only one assessed BB. Rectus femoris was the most studied muscle followed by gastrocnemius and vastus intermedius muscles. However, the accuracy results did not show large differences and the review could not identify the best muscle group to reflect the whole-body muscle mass[35].

What its authors observed was that gastrocnemius and rectus femoris MT as well as rectus femoris and biceps brachii CSA showed a moderate accuracy for the diagnosis of sarcopenia compared to other muscles or parameters such as vastus intermedius MT that showed a low precision[35]. These data point to BB as a good alternative to the rectus femoris in the assessment of sarcopenia.

There are fewer studies that analyse the relationship between BB muscle thickness and muscle mass. In our results, no significant correlation was obtained between these parameters in women, perhaps due to the smaller sample size of the female cohort. Furthermore, as has been obtained in a younger population, the correlation between MT and muscle mass is stronger in men than in women[24]. Whether muscle thickness is also be correlated with total body muscle mass in hospitalized woman could be subject of future studies.

The muscle mass measurement of BB offers advantages over others. Compared to the measurement of upper limb muscles for example, evaluation of the quadriceps requires more effort and is more time-consuming. This is due to having to partly undress and the need for a bed/ table to do the measurement on which additionally makes the measurement more uncomfortable. Besides, in the geriatric age, health problems that occur with oedema in lower limbs are frequent, which can lead to measurement errors of local muscle mass; or clinical situations, such as hip fracture, prevent the mobilization of the legs, which makes it difficult to place the patient in the correct position. In addition, the lower amount of subcutaneous adipose tissue at the brachial level compared to the thigh level offers another positive aspect since it improves the quality of the image.

Some authors have become interested in this muscle in recent years and have carried out studies trying to provide data and values about BB. Reference values have recently been published in healthy subjects in the same way as had previously been done with lower extremities muscles[24]. They used the same location as used in this study for muscle measurement and obtained an excellent ICC of 0.99, which demonstrates high reliability of the results. Furthermore, the correlations obtained between muscle mass assessed by BIA and muscle parameters (MT and CSA) were moderate to strong, as were those obtained in this study. Li et al. also obtained, in a population over 60 years, positive correlations between biceps brachii CSA and skeletal muscle mass index. Moreover, biceps brachii CSA was significantly higher in the group without sarcopenia than in the group with sarcopenia pointing to BB assessment as a feasible method to predict sarcopenia[36].

As a limitation of the study, it has to be mentioned that only older hospitalized persons were included which, despite being one of the populations with the highest risk of loss of muscle mass and sarcopenia, makes it difficult to generalize the conclusion to an entire older population. The fact that this is a pilot study also implies a clear limitation: the sample size. Therefore, future research projects using BB should extend their inclusion to all age-groups and the sample size to obtain more accurate results. Additionally, ultrasound is an operator-dependent technique. This could also be a limitation, however, in this case it could be a strength since the sonographer who performed all the study assessments was experienced and well trained. This is very important to minimize both intra- and interobserver variability.

Conclusion

From this study, we conclude that biceps brachii looks like a very good muscle measuring tool: easy, comfortable, fast, good correlated with total body muscle mass. More studies are needed to provide reference values in all age cohorts.

Ethics Approval

Approval was obtained by the Ethics Committee ZNA/ OCMW Antwerpen (OG 031 - 009).

Consent to participate

Each patient gave oral informed consent before starting the measurements and all data were anonymized within the trust before export for analysis.

Authors' contributions

All authors contributed substantially to the development of this manuscript. BA and SP designed the research question and study protocol. BA, SB and SP contributed towards recruitment and assessments of participants in the study. BA analysed and interpreted the results and was responsible for manuscript preparation. SB, AMC, MC, JTR and SP did a critical revision of the manuscript for important intellectual content. All authors read and approved the final version of the manuscript.

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