Acta Kinesiologica 19 (2025) Issue.1
DOI. 10.51371/issn.1840-2976.2025.19.1.4

Original Investigation

Differences between functionality status and muscle quality in older women

Mateusz Kamiński[a,†], Patrycja Bobowik[a,†], Ida Wiszomirska[a]
[a]Faculty of Rehabilitation, Józef Piłsudski University of Physical Education in Warsaw, Poland
[†]These author contributed equally as first author

Purpose: Sarcopenia is a progressive skeletal muscle disorder leading to increased risks of falls, fractures, and physical disability. This study aimed to investigate the relationship between bioelectrical impedance analysis (BIA) and functional testing in older women, emphasizing the importance of combining functional and strength assessments for a comprehensive evaluation of muscle quality.
Methods: The study involved 55 older women divided into two groups based on their performance in the 30-Second Chair Stand Test (30CST): Group 1 (≥15 repetitions) and Group 2 (<15 repetitions). Muscle strength (knee extensors and flexors), handgrip strength and body composition parameters were assessed.
Results: Statistically significant differences were observed between groups for knee extensors and flexors strength, back flexors strength, and handgrip strength ($P < .05$). Group 2 demonstrated weaker knee flexors, extensors and handgrip strength. BIA parameters revealed higher body fat mass and soft lean mass in Group 2 ($P < .05$). However, no significant differences were found in limb-specific lean mass normalized to height (L S.L.M./height^2). The findings highlighted the inadequacy of BIA alone in assessing muscle quality and the importance of functional testing.
Conclusions: Assessing muscle quality in older women requires a combination of functional tests like 30CST, and lower limb strength measurements. Functional training should be incorporated to enhance muscle quality and reduce the risk of sarcopenia-related impairments.

Keywords: sarcopenia, muscle strength, body composition, elderly, functional testing

Introduction

The novel index of functional capacity is muscle quality (MQ), there is no universal consensus on the definition or assessment method for MQ.[1] MQ is commonly defined as a ratio of muscle strength and muscle mass. The question is which factors can be contributed to this term and how these factors relate to muscle strength.[2] It is worth to mention that this explanation considers the functional importance of the structure, the general tissue features of the skeletal muscle, and, in the end, the ability to produce force.[3] It would seem that it is influenced by muscle composition, metabolism, and neuromuscular function. MQ should be defined as all muscle-associated physiological factors that influence the force-generating capability of skeletal muscle tissue. While the focus of improving muscular force generation traditionally centers on increasing muscle quantity (muscle hypertrophy), recent efforts have focused on improving MQ for enhance muscle function.[4] The distinction between MQ and muscle quantity is an important aspect of functional assessment as two individuals with similar mass may not be capable of producing equivalent amounts of force.[5] MQ is also defined as the amount of strength or power per unit of muscle mass. Highter MQ relates to increase muscle strength, function, physical performance, and vice versa.[6] The distinction between MQ and muscle quantity is an important aspect of functional assessment, as two individuals with similar muscle mass may not be capable of producing equivalent amounts of force. Similarly and counterintuitively, individuals with smaller amounts of muscle mass may be more effective at producing force than those with greater amounts. Differences in MQ between individuals may help explain why certain muscles are stronger than others, despite similar sizes. However, MQ may also vary between limbs, generating potential for injury if not properly corrected.[5] MQ is increasingly relief upon as a biomarker of muscle health in low functioning aging adult population. In the case of seniors, the level of the so-called functionality related to the level of everyday activity and self-service activities. Aging can lead to declines in muscle fibers quantity, quality, and strength.[7] Experiencing difficulty in activities of daily living (ADL) and relying on others is not only related to decreased quality of life but also increased likelihood of long-term nursing home placement.[8] There is a growing body of literature about functionality improvement in which older adults are trained on specific tasks, such as chair rise or movements needed to perform daily task to reduce disability in late life and as a result of various disease.[9–11]

Functionality depends on many factors, including proper functioning of the nervous system or the appropriate state of musculoskeletal system. While the condition of the nervous system can be improved by repetitive activities, the condition of the active musculoskeletal system can similarly be improved by exercises. There are many tools used in everyday physiotherapy practice to assess the level of functional fitness of seniors. One of them is the chair test recommended by EWGSOP2 (the European Working Group on Sarcopenia in Older People). The chair test has two variants, 30-second Chair Stand Test (30CST) and The Five Times Sit to Stand Test (FTSST). However, according to previous scientific reports, both of them are reliable and effective.[12]

The examination of muscle composition may provide additional insight into MQ which can circumvent some of the limitations associated with muscle strength measurements.[5] In clinical research, MQ has often been measured in terms of strength normalized to muscle mass as determined by dual-energy x-ray absorptiometry (DXA), which, unfortunately, is expensive and not readily available.[13] In addition, DXA examination allows the quality of the bone to be assessed.[14]

There are also many other tools available on the market for examining body composition components, including analyser using the bioelectrical impedance analysis (BIA). This test involves measuring the impedance of electrical resistance associated with the resistance and reactance of soft tissues by passing a low current through them. BIA appears to be a good screening tool due to its speed, safety, and ease of performance. It would seem that BIA results should show certain relationships with the presented functional status and muscle strength of seniors.BIA equipment does not measure muscle mass directly, but instead derives an estimate of muscle mass based on whole-body electrical conductivity.[15] BIA measurements can also be influenced by hydration status of the patient.[16]

Due to the ageing population, appropriate preventive measures are warranted. The basic premise of therapy for seniors is to maintain an adequate level of functionality, which is directly related to MQ. The aim of this research is to look for simple and practical tools to assess MQ in the context of the functionality of older women. Is the functionality of seniors more determined by muscle strength or body composition components measured by BIA?

Material and methods

Participants

The Inclusion criteria were: female gander, age 65 or older, be in good mental condition, and have a low level of physical activity and no prior strength training experience, as declared by the participants in the inclusion questionnaire. All participants provided written informed consent, prior to data collection. Exclusion criteria were a specific mental condition, communication problems, medications that might cause imbalance, diseases that cause imbalance (e.g., Parkinson's disease), multiple sclerosis, labyrinth diseases, advanced coronary disease, and a high cardiac risk, defibrillator, endoprosthesis. This study included 55 participants with age 72 years (± 7.29), body height 157.25 cm (± 6.58), body mass 70.08 kg (± 11.52), Body Mass Index (BMI) 28.38 kg/m^2 (± 4.74), Waist to Hip Ratio (WHR) .86 (± .09). Participants were divided into two groups based on their 30-Second Chair Stand Test (30CST) scores. Group one (group 1– $x \geq 15$ repetitions in 30CST, where x represents the number of repetitions) consisted of 16 women with a score of 15 repetitions or more. The age in Group one was 71.31 years (± 7.84), body height 158.16 cm (± 6.15), body weight 69.44 kg (± 11.05), BMI 26.40 kg/m^2 (± 4.81), WHR .82 (± .8). Group two (group 2– $x < 15$ repetitions in 30CST, where x represents the number of repetitions) consisted of 39 women who scored less than 15 repetitions. The age of the group 2 was 72.28 years (± 7.14), body height 153.13 cm (± 5.70), body weight 70.35 kg (± 11.84), BMI 29.20 kg/m^2 (± 4.52), WHR .88 (± .08).

Strength tests

The peak muscle torque [N·m] of the knee, elbow, trunk flexors and extensors were measured. The muscles were measured under isometric conditions (Maximum Voluntary Contraction) using a TBK2 and TBK3 JBA Staniak isometric torquemeter ("JBA" Zb. Staniak, Warsaw, Poland) with optimal 90° flexion in the tested joints. Hand grip strength was measured in kilograms (kg), with a hydraulic hand dynamometer SH501 (SAEHAN, Changwon, South Korea) calibrated by the manufacturer. The measurement was performed in sitting position with the elbow flexed at 90°, the forearm in neutral position and the wrist in 0° extension in accordance with the American Society of Hand Therapists recommendations. In all cases, the highest of three measurements was recorded using readouts from the mounted tensometric enhancer WPT004 (JD Jarosław Doliński Systemy Mikroprocesorowe, Warsaw, Poland), operating at a sampling frequency of 100 Hz with a 10 Hz filter applied. Dominant limb strength was used for statistical analysis. Upper limb dominance was established based on interview. To determine the dominance of the lower extremity, each participant performed a kicking task. They were asked to kick a stationary soccer ball at a target using their preferred lower extremity. The participants completed three trials of this activity. In all participants, the right upper limb and the right lower limb were found to be dominant.

Body composition analysis

Body composition analysis was measured using bioelectrical impedance analysis (BIA) using an Jawon Medical IOI-353 (Jawon Medical, Yuseong, South Korea). The examination was performed according to the manufacturer's instructions and all participants were examined before 12:00 am. The participants stood barefoot on the device holding the handles in their hands placed along the body, during the test, the person stood still until the device finished recording measurements. On this basis, percent of body fat (P.B.F), mass of body fat (M.B.F), lean body mass (L.B.M.), soft lean mass (S.L.M.), basal metabolic rate (B.M.R.), and proteins mass were determined. The result was processed using the BodyPass (Rice Lake, WI 54868 USA) software.

Functional test

A 30CST test was conducted. It was counted how many cycles from sitting to standing up the participant was able to complete in 30 seconds. Participants were divided into groups according to their 30CST results. We have adopted the standards given by the Fullerton test (Senior Fitness Test). The number of repetitions equal to and greater than 15 (Group 1) suggests that the participants had normal muscle strength, appropriate to their age, whereas the number of repetitions less than 15 (Group 2) indicates that the participants had low muscle strength.[17,18] Participants were introduced to the 30CST test during a practice session before taking the measurements proper. The training session included a demonstration of the test, verbal instructions, and a 10-second practice session. The participants were instructed to perform a full range of motion task using both lower limbs. The researchers advised the participants to try their best during the test and to perform as many cycles as possible from sitting to standing within 30 seconds. On the command: 'start', the participant began to perform the test. Participants started the test in a sitting position, with feet on the floor and arms crossed, positioned on an armless chair with a seat height of 45 cm, which was fixed to a wall. Two investigators participated in the test: the first investigator made sure that the chair remained stationary by placing one foot in front of the chair leg, thus keeping the back of the chair against the wall throughout the test, additionally the same investigator provided protection and motivation to the participant throughout the test. A second researcher was responsible for saying the 'start' command, counting the number of cycles and monitoring the stopwatch. If the participant completed more than half of a cycle by the end of the 30-second period, the researcher responsible for counting repetitions counted this incomplete cycle as one repetition.[19]

Statistical analysis

Statistical analysis was performed using STATISTICA v. 13.3 (TIBCO Software, Palo Alto, CA, USA). The normal distribution of the data was assessed using the Shapiro–Wilk test. Homogeneity of variance was tested by Levene's test. Simple cross-sectional ANOVA were performed. Moreover, ANOVA test for the main effects and factorial designs were performed. The level of significance was set at $P \leq .05$. An effect size was measured by Cohen's d. The interpretation of Cohen's d followed the conventional thresholds: values of .2 were considered small effects, .5 moderate effects, and .8 large effects.

Results

Analysis of Variance showed statistically significant differences between groups in the following parameters: handgrip strength (HGS), knee extensors strength (KES), knee flexors strength (KFS), Back flexors strength (BFS) ($P< .05$). For all parameters, Levene's test showed no statistically significant differences ($P> .05$). Detailed results of the above analysis can be found in Table 1.

Table 1. Differences in the strength values of various muscle groups by chair test results.

Parameter	Group 1	Group 2	*P*	*F*	Effect size
n	16	39	-	-	
HGS [kg]	19.81 ± 4.85	14.62 ± 3.93	.0001	17.28	1.176
EES [Nm]	20.43 ± 5.78	18.22 ± 5.65	.197	1.707	.387
EFS [Nm]	25.68 ± 8.36	21.93 ± 10.08	.195	1.722	.405
KES [Nm]	83.12 ± 33.57	63.48 ± 24.52	.009	7.334	.668
KFS [Nm]	47.84 ± 12.05	36.40 ± 14.99	.019	5.833	.841
BES [Nm]	148.06 ± 76.47	116.74 ± 43.98	.061	3.660	.502
BFS [Nm]	74.32 ± 24.20	57.08 ± 25.50	.025	5.336	.693

Legend 1. Group 1- x ≥ 15 repetitions in 30-second Chair Stand Test; Group 2- x < 15 repetitions in 30-second Chair Stand Test; HGS- Handgrip strength; EES- elbow extensors strength; EFS- elbow flexors strength; KES- knee extensors strength; KFS- knee flexors strength; BES- back extensors strength; BFS- back flexors strength; *P*– p value; *F*– F test, Effect size– Cohen's d

Analysis of Variance showed statistically significant differences between groups in the following parameters: percent body fat (P.B.F.), mass of body fat (M.B.F.), lean body mass (L.B.M.), soft lean mass (S.L.M.) ($P< .05$), while no statistically significant differences were found for the parameters determining the amount of soft lean mass in the limbs. For all parameters, Levene's test revealed no statistically significant differences in variance; therefore, comparisons were conducted ($P> .05$). Detailed results of the analysis are presented in Table 2.

Table 2. Differences in the values of body composition analysis parameters by 30CST results.

Parameter	Group 1	Group 2	*P*	*F*	Effect size
n	*16*	*39*	**-**	**-**	**-**
Right upper limb S.L.M [kg]	2.47 ± .28	2.64 ± .36	.114	2.587	-.527
Right lower limb S.L.M [kg]	6.96 ± .74	7.46 ± 1.02	.087	3.034	-.561
L S.L.M [kg]	18.82 ± 1.94	20.19 ± 2.76	.076	3.286	-.574
L S.L.M/height^2 [kg/m^2]	7.71 ± .89	8.12 ± .91	.132	2.342	-.456
P.B.F [%]	34.92 ± 5.22	38.08 ± 4.44	.027	5.181	-.652
M.B.F [kg]	22.79 ± 6.66	27.86 ± 6.82	.015	6.364	-.752
L.B.M [kg]	41.23 ± 3.84	44.44 ± 5.52	.038	4.523	-.675
S.L.M [kg]	37.62 ± 3.37	40.39 ± 4.96	.046	4.186	-.653

Legend 2. Group 1– x 15 repetitions in 30-second Chair Stand Test; Group 2– x< repetitions in 30-second Chair Stand Test; L S.L.M.– Limbs soft lean mass; L S.L.M./height^2– L S.L.M. adjusted for body size; L S.L.M.– P.B.F.– percent of body fat; M.B.F.– mass of body fat; L.B.M.– lean body mass; S.L.M.– soft lean mass; *P*– p value; *F*– F test, Effect size– Cohen's d

One-way ANOVA showed statistical significance at ($P= .00061$; $F= 6.78$; Wilks' lambda= .714) We used grip strength, flexor and extensor strength of the knee joint as the dependent variable, while as a qualitative predictor we used the score in the 30CST (Fig. 1A). Furthermore, one-way ANOVA showed no statistically significant differences ($P= .34$, $F= 1.14$, Wilk's lambda= .936) for the dependent variables right upper limb S.L.M., right lower limb S.L.M. and limbs soft lean mass adjusted for body size using height squared (L S.L.M./height^2) (Fig. 1B).

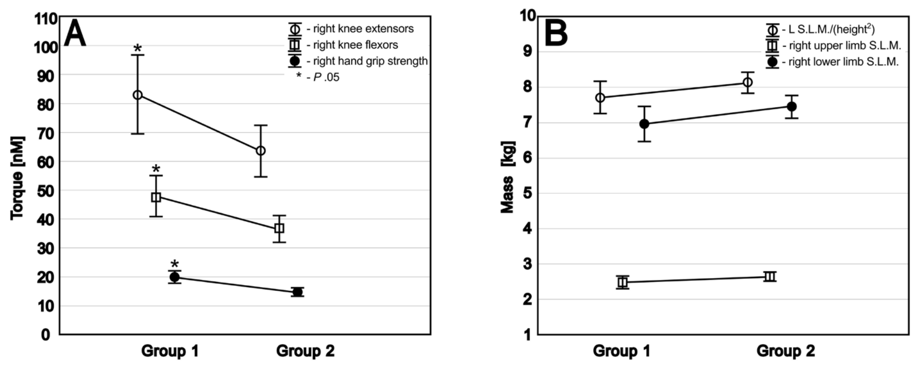

Figure 1. Muscle torque (A) and BIA (B) between the two groups

Discussion

In the above study, we investigated whether there is a relationship between results from BIA and functional testing. We showed the relevance of functional testing, since the determination of sarcopenia based on electrical bioimpedance testing alone may be insufficient.

MQ refers to the functional capacity of muscles and is closely related to muscle strength, power, and mobility in seniors. It is influenced by factors such as muscle composition, metabolism, and neuromuscular function. Assessing MQ is important for evaluating physical function and designing interventions to improve muscle strength and mobility in older adults. Measurement of muscle strength is recommended by EWGOSP2, moreover when sarcopenia is clinically suspected, muscle strength testing is used. In previous studies have already established that the decrease in muscle strength during aging is substantially greater than the decrease in SMM (total body Skeletal Muscle Mass).[18]

Scientific reports show that screening seniors for sarcopenia is not a clinical standard, and awareness of the disease itself is low.[20] The European Working Group on Sarcopenia in Older People (EWGOSP) defines sarcopenia as a progressive and generalized skeletal muscle disorder that is associated with an increased likelihood of adverse sequelae, i.e.: falls, fractures, physical disability and even death.[18] The incidence of sarcopenia varies and is related to lifestyle, diet and level of physical activity.[21]

The 30CST is a recommended tool for assessing muscle strength by EWGOSP2 and for assessing locomotor ability (moving from one place to another) by the World Health Organization but the EWGOSP does not specify cut-off points for sarcopenia in the 30CST test.[18] Sawada et al. based on a cross-sectional study of the Japanese population (n= 678), determined the cut-off point in the 30CST for the diagnosis of sarcopenia to be 15 repetitions for women (sensitivity, 76.4%; specificity, 76.8%) and 17 for men (sensitivity, 76.4%; specificity, 76.8%).[22] These results coincide with the recommendations of the Fullerton test, and the cut-off points adopted in our study.

In our study, statistically significant differences were found for the knee flexors and extensors muscles, back flexor strength and for hand grip strength, between the groups. The group that achieved less than 15 repetitions in the 30CST (Group 2) had statistically significantly weaker knee extensors and flexors strength. This confirms that 30CST scores may be a predictor of knee joint extensors and flexors strength in older women. McCarthy et al. showed in their study that strength of the ankle flexors, soleus, hip flexors and knee extensors are important and necessary indicators, but only moderate predictors of 30CST scores, this would explain the significant differences in the strength of the trunk flexor muscles in our study, as some of the muscles responsible for trunk flexion also flex the hip joint (e.g. ilio-psoas muscle).[23] Gkrilias et al. showed statistically significant correlations between the isokinetic strength of the quadriceps and popliteal tendons and the results in the 30SCT in a group of patients with knee osteoarthritis.[24] In another study, Alotaibi et al. demonstrated that the performance of 30 CSTs predicted peak power parameters in the counter movement jump test and jump height independently of gender, body height and body weight.[25] Researchers agree that the 30CST is easy to perform in the clinic, does not require sophisticated equipment and it is a multifaceted test assessing not only lower limb strength, but also variables such as sensorimotor, balance and psychological parameters.[23] Worth adding is the fact that in patients over 75 years old with heart failure, 30CST was independently associated with VO2 peak, so it can be used as a cheap and safe measurement to assess exercise tolerance.[26] Makizako et al. also found in their prospective cohort study (n= 4335) that the Sit to Stand tests (STS) is a good predictor of future disability in community-dwelling older adults identified as requiring care in 8 possible categories (grooming/bathing, eating, toileting, transferring, assistance with instrumental activities of daily living, behavioral problems, rehabilitation and medical services).[27]

Yoshiko et al. investigated the relationship of functional parameters, among others, in the Ten Times Sit-to-Stand Test in the elderly with skeletal muscles, and showed that the thickness of the quadriceps muscle of the thigh on ultrasound was significantly correlated with the time to perform the Ten Times Sit-to-Stand Test, while they showed no relationship of the thickness of the quadriceps muscle of the thigh with the time to perform the Five Times Sit-to-Stand Test (FTSST).[28] Based on this study we can speculate that the 30CST may be a better choice in the context of assessing MQ than the FTSST, while this requires further research.

It appears that functional training, which can be described as goal-directed training, stating that “function is essentially the goal”, may be helpful for impaired muscle strength in the elderly population. Therefore, functional training can be any type of training that is done to improve a specific movement or activity.[29] While muscle weakness with age is closely associated with functional decline in the elderly, aging also affects other motor skills critical to ADLs, such as coordination.[30] However, recent evidence suggests that the quality of muscle tissue may be more functionally relevant than its quantity. MQ has been emerging as a means to elucidate and describe the intricate intramuscular changes associated with muscle performance in the context of aging and sarcopenia.

In our study, the largest statistically significant differences (*P*= .0001) were observed between the chair test and Handgrip Strength. The mean values of repetitions for the Group 1 were 19.81 repetitions (± 4.85), while for the Group 2 was 14.62 repetitions (± 3.93), which is below the sarcopenia cutoff point for women. This value, according to EWGOSP2 guidelines is16 kg. Yee et al.[31] in their study do not show such strong effects between STS testing and grip strength and recommend caution when using grip strength as the sole proxy measure for lower limb strength or performance. It is worth mentioning that to date, few researchers have used apparatus to test muscle force moments in statics for evaluating sarcopenia. This is understandable due to the price and lack of widespread availability of these devices. Interestingly, Abdalla et al. [32] used the Biodex System 4 device to dynamometrical assess knee extensors muscles work among individuals with and without sarcopenia. They noted a clear but not statistically significant difference between the force released by women without sarcopenia (41.89 kg) and women with sarcopenia (30.32kg). A similar difference was noted in the group of male participants (71.06 and 50.89 kg). The researchers noted that the dynamic strength of the knee joint extensors group decreases earlier in life than the decrease in hand tightness strength. This could be used to identify sarcopenia earlier and apply earlier treatment to ensure better muscle function in the elderly.[32] In addition, the age-related reduction in muscle mass and strength in the lower body is more significant than in the upper body, due to decreased physical activities like walking, running, and stair-climbing that would typically affect the lower body more, along with compensatory upper body movements like engaging arm muscles in everyday tasks such as getting up from a chair.[33]

The literature shows that BIA is a good measurement tool for estimating percent body fat within the normal range. However, it shows a tendency to overestimate the measurement results of thin people and underestimate the results of obese people compared to DEXA testing, which is the gold standard.[34] In contrast, when checking for the ability to capture tissue changes in the process of weight loss, bioimaging, compared to DEXA, significantly overestimates lean tissue mass and underestimates fat mass. With respect to this indicator, electrical bioimpedance has a measurement error of up to 8%. In most cases, however, it does not exceed 4%. Comparisons of the accuracy of the bioimpedance method to DEXA results alone show a difference of about 6%, confirming this ceiling on the precision of BIA measurements. There is also a marked tendency to underestimate the result of body fat measured by the bioimpedance method.[35]

In the present study, statistically significant differences were found in the body mass components P.B.F., M.B.F., L.B.M., S.L.M. Interestingly, those in the group representing a lower fitness level (Group 2), had higher mean values for all the parameters, including more S.L.M. corresponding to the amount of muscle mass. These results may be related to the overall higher weight of the women in this group (BMI= 29.20 kg/m^2 (± 4.52); WHR= .88 (± .08)). According to the WHO, a WHR above .85 indicates obesity, while a BMI of 29.2 is at the upper limit of pre-obesity and near obesity class I. A higher value of soft tissue and lean body mass should predispose toward greater muscular strength. However, according to Reijnierse et al.[36] patients who have low muscle strength do not necessarily have low muscle mass, as loss of muscle strength occurs faster than loss of muscle mass. It should be noted that the women studied were participants at a third-age university and two rehabilitation clinics. They came to each of these places independently, which may indicate a good level of functioning, and according to Wiszomirska et al.[37] activity levels significantly reduce body fat percentage and BMI. Based on previous literature, we know that muscle mass is correlated with body size, indicating that people with larger body size may have more muscle mass (S.L.M.).[38] Therefore, in our study, following the recommendations of other authors, we included in the analysis the muscle mass of the testing limbs and limb muscle mass adjusted for body size using height squared (L S.L.M./height^2).[39] No statistically significant differences were found for total soft tissue mass normalized to height, nor for soft tissue mass for the limbs. It is worth noting that the mean values for the muscle mass of the testing limbs and L.S.M./height^2 were higher in the group of older women who performed worse in the 30CST test. Yee et al. in their study showed a weak inverse correlation between STS and muscle mass.[31] These observations may suggest a diminished ability to fully recruit motor units in the group with poorer functional outcomes. Recruitment of an adequate number of motor units is necessary to obtain adequate strength when performing daily life tasks, such as walking up and down stairs or getting up and down from a chair.

The group of women who scored worse on the 30CTS (Group 2) was statistically significantly different in terms of M.B.F (mass of body fat) (*P*= .015, Cohen's *d*= - .752), from the group of women who scored normal on the 30 CST. These results confirm previous reports suggesting that body fat adversely affects muscle performance, particularly in functional performance of the lower limbs in STS.[40] This additionally suggests that the 30CST could serve as a suitable proxy in the assessment of MQ. In the above study, we did not add an age breakdown, because in the study group, a two-factor ANOVA analysis showed no age or chair factor resulted. No interaction was observed between age and the chair test, so this article undertook a single-group analysis. This may be due to age, there was a shortage of young women who scored below 15 repetitions in the 30 CST. We recommend that past studies be expanded to include this variable.

Practical Applications

The findings of this study highlight the importance of combining functional testing and strength measurements with body composition assessments to evaluate MQ in older women comprehensively. The 30-Second Chair Stand Test (30CST) demonstrated its utility as a quick, reliable, and cost-effective tool to identify deficits in lower limb muscle strength and functional performance. This can serve as a critical component in routine screenings for sarcopenia and fall risk in clinical and community settings. Healthcare providers, rehabilitation specialists, and fitness professionals should consider incorporating functional training programs into interventions targeting older adults. Exercises focusing on lower limb strength, balance, and proprioception may help improve MQ and reduce the risk of falls and functional decline. Specific attention should be given to individuals with higher body fat percentages or diminished motor unit recruitment, as identified by weaker 30CST performance, to design tailored interventions addressing these deficits. Given the limitations of bioelectrical impedance analysis (BIA) alone in detecting MQ, practitioners are encouraged to use it in conjunction with functional tests and strength assessments for more accurate diagnoses and intervention planning.

Conclusions

1. The results of the electrical impedance test do not determine the level of functional fitness of older women, muscle quality should not be assessed solely on the basis on this study
2. Isometric muscle strength testing is an effective method for assessing muscle quality, but it may not be sufficient on its own, as it does not consider factors such as muscle endurance, coordination, or neuromuscular efficiency.
3.To determine muscle quality, we recommend using a combination of functional tests and lower limb muscle strength measurements.

Acknowledgments

The authors thank the participants for their participation in the training programme. The authors gratefully thank the university colleagues for their cooperation and support during the writing process.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Ethical Committee approval

SKE01 – 65/2017

ORCID

Mateusz Kamiński ID https://orcid.org/0009-0009-8830-4693
Patrycja Bobowik ID https://orcid.org/0000-0003-0166-3810
Ida Wiszomirska ID https://orcid.org/0000-0002-5838-601X

Topic

Public Health

Conflicts of interest

The authors have no conflicts of interest to declare.

Funding

No funding was received for this investigation.

Author-s contribution

M.K and P.B. made substantial contributions to the conception and design of the work, while M.K, P.B., I.W, contributed to data acquisition, analysis, and interpretation.
Drafting and Critical Revision: The initial draft was prepared by M.K and P.B., with critical revisions contributed by M.K, P.B., and I.W, to enhance intellectual content.
Final Approval: All authors (M.K, P.B., I.W) provided final approval for the version to be published.
Accountability and Integrity: Each author agrees to be accountable for all aspects of the work, ensuring the accuracy and integrity of all parts are thoroughly investigated and resolved.

References

1. McGregor RA, Cameron-Smith D, Poppitt SD. It is not just muscle mass: a review of muscle quality, composition and metabolism during ageing as determinants of muscle function and mobility in later life. *Longev Healthspan.* 2014;3(1). doi:10.1186/2046-2395-3-9
2. Kuschel LB, Sonnenburg D, Engel T. Factors of Muscle Quality and Determinants of Muscle Strength: A Systematic Literature Review. *Healthcare (Basel).* 2022;10(10). doi:10.3390/HEALTHCARE10101937
3. Mangine GT, Stratton MT, Almeda CG, et al. Physiological differences between advanced CrossFit athletes, recreational CrossFit participants, and physically-active adults. *PLoS One*. 2020;15(4):e0223548. doi:10.1371/JOURNAL.PONE.0223548
4. Correa-de-Araujo R, Harris-Love MO, Miljkovic I, Fragala MS, Anthony BW, Manini TM. The Need for Standardized Assessment of Muscle Quality in Skeletal Muscle Function Deficit and Other Aging-Related Muscle Dysfunctions: A Symposium Report. *Front Physiol.* 2017;8. doi:10.3389/FPHYS.2017.00087
5. Naimo MA, Varanoske AN, Hughes JM, Pasiakos SM. Skeletal Muscle Quality: A Biomarker for Assessing Physical Performance Capabilities in Young Populations. *Front Physiol.* 2021;12. doi:10.3389/FPHYS.2021.706699
6. Brown JC, Harhay MO, Harhay MN. The Muscle Quality Index and Mortality among Males and Females. *Ann Epidemiol.* 2016;26(9):648. doi:10.1016/J.ANNEPIDEM.2016.07.006
7. Eby SF, Cloud BA, Brandenburg JE, et al. Shear wave elastography of passive skeletal muscle stiffness: Influences of sex and age throughout adulthood. *Clin Biomech (Bristol)*. 2015;30(1):22-27. doi:10.1016/J.CLINBIOMECH.2014.11.011
8. Luppa M, Luck T, Weyerer S, König HH, Brähler E, Riedel-Heller SG. Prediction of institutionalization in the elderly. A systematic review. *Age Ageing.* 2010;39(1):31-38. doi:10.1093/AGEING/AFP202
9. Bobowik P, Gajewski J, Wiszomirska I, Maciejewska-Skrendo A, Leźnicka K, Kaczmarczyk K. The Impact of Resistance Training on Equilibrium Abilities and Quality of Life in Older Adults after SARS-CoV-2 Survival. *J Clin Med.* 2024;13(10). doi:10.3390/JCM13102747
10. Liu CJ, Latham NK. Progressive resistance strength training for improving physical function in older adults. *Cochrane Database Syst Rev.* 2009;2009(3). doi:10.1002/14651858.CD002759.PUB2
11. Dündar Ö, Can S, Eliaçık S, Yıldırım T. The effects of a hatha yoga-based exercises program on pain with migraine in women: A randomized controlled study. *Biomed Hum Kinet.* 2024;16(1):305-313. doi:10.2478/BHK-2024-0032
12. Applebaum E V., Breton D, Feng ZW, et al. Modified 30-second Sit to Stand test predicts falls in a cohort of institutionalized older veterans. *PLoS One.* 2017;12(5). doi:10.1371/JOURNAL.PONE.0176946
13. Colley D, Cines B, Current N, et al. Assessing Body Fatness in Obese Adolescents: Alternative Methods to Dual-Energy X-Ray Absorptiometry. *Digest (Wash D C)*. 2015;50(3):1-7 PMCID: PMC4936189

14. Kopiczko A. Bone mineral density in the various regions of the skeleton in women with subclinical hypothyroidism: the effect of biological factors, bone turnover markers and physical activity. *Biomed Hum Kinet.* 2024;16:1-11. doi:10.2478/bhk-2024-0001
15. Yamada Y, Nishizawa M, Uchiyama T, et al. Developing and Validating an Age-Independent Equation Using Multi-Frequency Bioelectrical Impedance Analysis for Estimation of Appendicular Skeletal Muscle Mass and Establishing a Cutoff for Sarcopenia. *Int J Environ Res Public Health.* 2017;14(7):809. doi:10.3390/IJERPH14070809
16. Gonzalez MC, Heymsfield SB. Bioelectrical impedance analysis for diagnosing sarcopenia and cachexia: what are we really estimating? *J Cachexia Sarcopenia Muscle.* 2017;8(2):187. doi:10.1002/JCSM.12159
17. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Res Q Exerc Sport.* 1999;70(2):113-119. doi:10.1080/02701367.1999.10608028
18. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing.* 2019;48(1):16-31. doi:10.1093/AGEING/AFY169
19. Lein DH, Alotaibi M, Almutairi M, Singh H. Normative Reference Values and Validity for the 30-Second Chair-Stand Test in Healthy Young Adults. *Int J Sports Phys Ther.* 2022;17(5):907. doi:10.26603/001c.36432
20. Mziray M, Żuralska R, Siepsiak M, Domagała P. Sarcopenia - a marginalized problem of the old age. *Pielpol.* 2017;65(3):506-513. doi:https://doi.org/10.20883/pielpol.2017.69
21. Shafiee G, Keshtkar A, Soltani A, Ahadi Z, Larijani B, Heshmat R. Prevalence of sarcopenia in the world: a systematic review and meta- analysis of general population studies. *J Diabetes Metab Disord.* 2017;16(1). doi:10.1186/S40200-017-0302-X
22. Sawada S, Ozaki H, Natsume T, et al. The 30-s chair stand test can be a useful tool for screening sarcopenia in elderly Japanese participants. *BMC Musculoskelet Disord.* 2021;22(1):1-6. doi:10.1186/S12891-021-04524-X/FIGURES/2
23. McCarthy EK, Horvat MA, Holtsberg PA, Wisenbaker JM. Repeated chair stands as a measure of lower limb strength in sexagenarian women. *J Gerontol A Biol Sci Med Sci.* 2004;59(11):1207-1212. doi:10.1093/GERONA/59.11.1207
24. Gkrilias P, Tsepis E, Kokkalis Z, Panagiotopoulos E, Megas P. The relationship between isokinetic strength and functional performance tests in patients with knee osteoarthritis. *J Phys Ther Sci.* 2018;30(6):888-891. doi:10.1589/JPTS.30.888
25. Alotaibi MM, Almutairi MK, Singh H, Ithurburn MP, Lein DH. 30-Second Chair Stand Test Predicts Countermovement Jump Performance in Young Adults. *Sports Health*. 2022;15(3):452. doi:10.1177/19417381221105040
26. Kobayashi T, Iwasaki T, Kurata H, Nikaido A, Hata Y. The 30-second chair stand test (CS30) as a predictor of exercise tolerance in elderly individuals (≥75 years) with stage A/B heart failure. *Int J Cardiol Heart Vasc*. 2024;53:101442. doi:10.1016/J.IJCHA.2024.101442
27. Makizako H, Shimada H, Doi T, et al. Predictive Cutoff Values of the Five-Times Sit-to-Stand Test and the Timed "Up & Go" Test for Disability Incidence in Older People Dwelling in the Community. *Phys Ther.* 2017;97(4):417-424. doi:10.2522/PTJ.20150665
28. Yoshiko A, Ogawa M, Shimizu K, et al. Chair sit-to-stand performance is associated with diagnostic features of sarcopenia in older men and women. *Arch Gerontol Geriatr.* 2021;96:104463. doi:10.1016/J.ARCHGER.2021.104463
29. Liu C ju, Shiroy DM, Jones LY, Clark DO. Systematic review of functional training on muscle strength, physical functioning, and activities of daily living in older adults. *Eur Rev Aging Phys Act.* 2014;11(2):95-106. doi:10.1007/S11556-014-0144-1
30. Seidler RD, Bernard JA, Burutolu TB, et al. Motor Control and Aging: Links to Age-Related Brain Structural, Functional, and Biochemical Effects. *Neurosci Biobehav Rev.* 2009;34(5):721. doi:10.1016/J.NEUBIOREV.2009.10.005
31. Yee XS, Ng YS, Allen JC, et al. Performance on sit-to-stand tests in relation to measures of functional fitness and sarcopenia diagnosis in community-dwelling older adults. *Eur Rev Aging Phys Act.* 2021;18(1):1-11. doi:10.1186/S11556-020-00255-5/TABLES/5
32. Johansson J, Grimsgaard S, Strand BH, Sayer AA, Cooper R. Comparing associations of handgrip strength and chair stand performance with all-cause mortality-implications for defining probable sarcopenia: the Tromsø Study 2015-2020. *BMC Med.* 2023;21(1). doi:10.1186/S12916-023-03172-3
33. Candow DG, Chilibeck PD. Differences in Size, Strength, and Power of Upper and Lower Body Muscle Groups in Young and Older Men. . *J Gerontol A Biol Sci Med Sci.* 2005;60(2):148-156. doi:10.1093/GERONA/60.2.148
34. Sun G, French CR, Martin GR, et al. Comparison of multifrequency bioelectrical impedance analysis with dual-energy X-ray absorptiometry for assessment of percentage body fat in a large, healthy population. *Am J Clin Nutr.* 2005;81(1):74-78. doi:10.1093/AJCN/81.1.74
35. Sudha V, Anjana M, Mohan D, Farooq S, Deppa R, Viswanathan M. Validation of body fat measurement by skinfolds and two bioelectric impedance methods with DEXA – the Chennai Urban Rural Epidemiology Study [CURES-3]. *J Assoc Physicians India.* 2004;11:52:877-81. PMID: 15906838.
36. Reijnierse EM, Buljan A, Tuttle CSL, et al. Prevalence of sarcopenia in inpatients 70 years and older using different diagnostic criteria. *Nurs Open.* 2018;6(2):377-383. doi:10.1002/NOP2.219
37. Wiszomirska I, Kaczmarczyk K, Błazkiewicz M, Wit A. The Impact of a Vestibular-Stimulating Exercise Regime on Postural Stability in People with Visual Impairment. *Biomed Res Int.* 2015;2015. doi:10.1155/2015/136969
38. Kim KM, Jang HC, Lim S. Differences among skeletal muscle mass indices derived from height-, weight-, and body mass index-adjusted models in assessing sarcopenia. *Korean J Intern Med.* 2016;31(4):643. doi:10.3904/KJIM.2016.015
39. Cawthon PM, Peters KW, Shardell MD, et al. Cutpoints for Low Appendicular Lean Mass That Identify Older Adults With Clinically Significant Weakness. *J Gerontol A Biol Sci Med Sci.* 2014;69(5):567-575. doi:10.1093/GERONA/GLU023

40. Marcus RL, Addison O, Dibble LE, Foreman KB, Morrell G, Lastayo P. Intramuscular Adipose Tissue, Sarcopenia, and Mobility Function in Older Individuals. *J Aging Res.* 2012;2012(1):629637. doi:10.1155/2012/629637

Corresponding information:

Received: 20.01.2025.
Accepted: 31.01.2025.

Correspondence to: Mateusz Kamiński MSc PT
University: Faculty of Rehabilitation Józef Piłsudski
University of Physical Education in Warsaw,
Warsaw, Poland, Marymoncka, 34
00-968 Warsaw, Poland
E-mail: mateusz.kaminski@awf.edu.pl