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ORIGINAL ARTICLE

Sarcopenia quality-of-life questionnaire (SarQoL)®: translation, cross-cultural adaptation and validation in Turkish

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Abstract

Background The sarcopenia quality-of-life (SarQoL)® questionnaire is a multidimensional sarcopenia specific tool designed for community dwelling older adults.

Aims The aim of this study was to translate, to cross-culturally adapt and validate the SarQoL® questionnaire to assess sarcopenia-related quality of life in Turkish older adults.

Methods The validation process was performed in two sections: the first section constituted the translation with cross-cultural adaptation of SarQoL® into Turkish. Second section constituted the clinical validation study. To validate the Turkish version of the SarQoL®, we assessed its validity (discriminative power, construct validity), reliability (internal consistency, test–retest reliability) and floor/ceiling effects.

Results One hundred community-dwelling subjects (mean age: 74.7 ± 6.1 years) were evaluated. The EWGSOP2 consensus diagnostic criteria were used to diagnose probable sarcopenia. A database including 1437 older adults, with complete evaluation of sarcopenia parameters, served to define low global muscle function. Results revealed a good discriminative power: subjects with probable sarcopenia had higher total scores compared to non-sarcopenic subjects (50 ± 16 vs. 68.9 ± 16.9, $p < 0.001$) a high internal consistency (Cronbach's alpha: 0.88), consistent construct validity and excellent test–retest reliability (intraclass correlation coefficient: 0.97, 95% confidence interval: 0.94–0.98). There was no floor/ceiling effect.

Conclusion The Turkish version of the SaQoL® questionnaire was found to be reliable and valid for the measurement of quality of life of sarcopenic patients and is, therefore, available for use in clinical research and practice. This validation could enable use of the SarQoL® tool in the eastern populations more confidently.

Keywords Quality of life · Sarcopenia · SarQoL · Translation · Validation

Introduction

Sarcopenia is a progressive and generalized age-related skeletal muscle disorder associated with increased likelihood of adverse outcomes including falls, fractures, physical disability, and mortality [1, 2]. Sarcopenia impairs ability to perform activities of daily living, leads to mobility disorders and loss of independence; increases need for long-term care placement, therefore, impairs quality of life (QoL). Assessment of QoL-related to sarcopenia, therefore, constitutes an important aspect of sarcopenia assessment. This is important both to document the QoL problems associated with sarcopenia, its longitudinal changes and possible effect of a given treatment. Until recently, few studies were available to determine the relationship between sarcopenia and QoL in older adults [3–8]. However, in these studies, since

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a sarcopenia-specific QoL assessment tool was not present, some nonspecific generic questionnaires, i.e., the 36-item Short-Form Health Survey (SF-36), the European Quality-of-Life 5-Dimension (EQ5D) questionnaire, were used. Yet, it is important to evaluate the impact of sarcopenia on health-related QoL using a disease-specific QoL tool. In the context of this need, Beaudart et al. developed and validated the first specific patient-based instrument for measuring QoL in sarcopenic patients, the SarQoL® questionnaire, in 2015 in French. It is composed of 22 questions including in 55 items rated on a four-point Likert scale [9]. The items are organized into seven domains; physical and mental health, locomotion, body composition, functionality, activities of daily living, leisure activities, and fears. The total scoring of the SarQoL® questionnaire ranges from 0 (worst imaginable health) to 100 (best imaginable health). In accordance with the global need for a sarcopenia specific QoL assessment tool, it has been translated into 28 languages under the leadership of the creators [Charlotte Beaudart (CO), Olivier Bruyere (OB)]. So far, its cross-cultural adaptation and psychometric validation has been performed in seven (English, Romanian, Dutch, Polish, Spanish, Greek, and Hungarian) languages [10–16].

The diversity and lack of consensus in definition, diversity of cut-off values and evaluation tools caused significant heterogeneity in researches including the prevalence studies. Nonetheless, a meta-analysis published in 2017 which included 35 studies with community-dwelling participants aged 60 years or older and assessed sarcopenia by the EWGSOP criteria, has provided the assessment of the prevalence of sarcopenia. They reported that among healthy adults aged ≥ 60 years, an overall prevalence of 10% (95% CI = 8–12%) for men and 10% (95% CI = 8–13%) for women [17]. In Turkey, the prevalence of sarcopenia also differs between the studies using different definitions/techniques for sarcopenia. It has been reported in community dwelling older adults between 0.8 and 14% [18–20]. In a very recent study, we reported probable sarcopenia prevalence as 10.2% by EWGSOP2 suggested handgrip strength cutoffs (< 27 kg in males, < 16 kg in females) among 392 community-dwelling outpatient older adults applied to a university hospital [21]. In hospital and nursing home settings, both the prevalence and incidence of sarcopenia are likely to be significantly higher. In a study conducted in a nursing home, the prevalence of sarcopenia determined by evaluating muscle mass was found to be 85.4% [22], while the prevalence of sarcopenia determined by evaluating handgrip strength was found to be 68% [23]. In another study the prevalence of sarcopenia determined by EWGSOP criteria was found to be 29% [24]. These numbers highlight the need to treat sarcopenia and the need for tools such as SarQoL to assess the impact of sarcopenia on quality of life.

In this study, we aimed to translate, to cross culturally adapt and validate the SarQoL® questionnaire in Turkish, representing the most eastern culture studied so far, concurrent with the need in this regard.

Materials and methods

Study population

Patients, who applied to the geriatric outpatient clinics at two different university hospitals, were invited consecutively between May 2017 and May 2019 to participate in this study. The exclusion criteria were as follows: patients who were immobilized, had depression or dementia (assessed via clinical interview), unable to cooperate, understand and/or complete the questionnaires, technical aspects that would preclude assessment with bioimpedance analysis (BIA), i.e., edema, implantable pacemaker. Informed consent was obtained from all participants. The study was conducted in accordance with the principles of the Helsinki Declaration. The study was approved by the local ethics committee (number: 2018/961).

Assessment of sarcopenia

Height and weight were measured regularly using a standardized stadiometer. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Sarcopenia was diagnosed by the EWGSOP2 diagnostic criteria. Presence of low muscle strength provided that there are no secondary causes, such as stroke, peripheral vascular disorders, significant hand osteoarthritis, was diagnosed as probable sarcopenia. Presence of low muscle strength and low muscle mass (LMM) was diagnosed as confirmed sarcopenia. Presence of low muscle strength, low muscle quantity/quality and low physical performance was diagnosed as severe sarcopenia.

Muscle mass was assessed with bio-impedance analysis (BIA) using a Tanita-BC532 model body analysis monitor. Fat free mass (FFM) was measured by BIA and total skeletal muscle mass (SMM) was calculated by the following equation: SMM (kg) = 0.566 × FFM [25]. Absolute total SMM was adjusted by height squared (SMM/ht^2) [26]. The EWGSOP2 suggested use of standard cutoff values for appendicular SMM. However, when total SMM was assessed instead of appendicular SMM, the use of national total SMM thresholds, if available, has been suggested by the EWGSOP2 authors [27]. In line with this suggestion, the LMM thresholds were assessed according to the national data that is defined by lower than two standard deviation of young reference population and were as follows: muscle

mass adjusted by height^2 for women < 7.4 kg / m^2 and for men < 9.2 kg / m^2 [28].

Muscle strength was assessed by hand grip strength using a Jamar hydraulic hand dynamometer with a validated protocol [29, 30]. Grip strength was measured in sitting position, elbow in 90º flexion and wrist in neutral position. The participants were asked to apply the maximum grip strength for three times with both left and right hands. The maximal measured grip strength was regarded as the grip strength. The cut-off points recommended by the EWGSOP2 were used for low hand grip strength (27 kg for men, 16 kg for women) [1].

To evaluate physical performance, we used the gait speed test. Gait speed was assessed by the subjects walking 4 m with usual speed. The cut-off points which was 0.8 m/s for each sex indicated poor physical performance. All of the measurements were made by the same health profession -a geriatric physiotherapist- qualified to perform these measurements previously.

Translation and cross-cultural adaptation

The translation and cultural adaptation processes were carried out in five stages according to the guidelines [31]. In version the first stage, translation from English to Turkish was made by two bilingual translators who were Turkish native speakers. One of them had a medical background, the other being novice in the topic of the questionnaire. The translators provided a written report with comments to highlight challenging phrases or uncertainties and the rationale for specific linguistic choices made. The second stage is the synthesis of these 2 translations (version 1). In the third stage, two bilingual translators having English as their first language and blinded to the original version of the SarQoL® independently translated 'version 1' back into English. In the fourth stage, an expert committee composed of two methodologists (biostatisticians), one health professional, one Turkish lecturer and four translators, reviewed to compare the backward translations with the English questionnaire. For cultural adaptation, some important points have arisen. They have been resolved by close e-mail interaction with the creators of the questionnaire. After resolution of those issues with the creators of the SarQoL® questionnaire, 'version 2' has been formed. The final stage was the pretest stage, in which the version 2 was applied to 10 subjects, to test the comprehension of the questions. At the end of this stage, the version 3, which was the final version of the SarQoL-TR (Turkish)®, was set.

Psychometric performance test

The methodology applied for the validation of the English version of the SarQoL® was followed and completed in two phases. SPSS version 21 program was used for statistical analysis. Normality of the variables was assessed by the Shapiro–Wilk test. Numerical variables were reported as mean ± standard deviation for normally distributed variables and as median (minimum–maximum) for non-normally distributed continuous variables. Categorical variables are shown as frequencies and percentages. Two groups were compared using the independent samples *t*-test or Mann–Whitney *U* test, whichever was appropriate. Correlations between numerical parameters were analyzed with Spearman's rho correlation test. *p* value of less than 0.05 was considered statistically significant.

First phase

In the first phase, we assessed the discriminative power, internal consistency and the presence of floor and ceiling effects of the SarQoL-TR® which was filled by all participants.

(a) *Discriminative power:* The population sample was divided into probable sarcopenic and non-sarcopenic subjects. The independent samples t-test was performed to assess the difference in overall and individual domain scores between the sarcopenic and non-sarcopenic subjects. We assumed that QoL was better in non-sarcopenic patients than in those with sarcopenia.

(b) *Internal consistency:* Questionnaire homogeneity was estimated by internal consistency. To measure it, Cronbach's alpha coefficient was used. A value of greater than 0.7 indicates a high level of internal consistency [32].

The correlation of each domain with the total SarQoL-TR® score was also assessed using Spearman's correlation, since the scores were not normally distributed. A correlation above 0.81 is considered excellent, 0.61–0.80: very good, 0.41–0.60: good, 0.21–0.40: acceptable and, less than 0.20: insufficient [32].

(c) *Floor and ceiling effects:* Floor and ceiling effects were considered present if more than 15% of participants achieved the worst score and the best score, respectively [33].

Second phase

In the second phase, the construct validity and the test–retest reliability of the questionnaire was determined. These analyses were planned to be performed on sarcopenic subjects but, when using confirmed sarcopenia or probable sarcopenia definitions of the EWGSOP2, there were only a limited number of sarcopenic subjects: only five subjects with confirmed sarcopenia and 27 subjects with probable sarcopenia. At least 50 subjects are needed

for construct validity analyses and hence, the number of sarcopenic subjects identified by standard sarcopenia definitions were insufficient for the validation analyses [10, 33]. In this regard, the creators of the original SarQoL® questionnaire (CB, OB), who also coordinate the cross-cultural adaptation and validation studies of SarQoL® in different languages, were contacted. In accordance with their guidance, we modeled the method they followed in the English validation study of the SarQoL® in which they encountered similar shortage of sarcopenic subjects by the EWGSOP1 definition of sarcopenia. The same method applied for the validation of the English version of the SarQoL® was followed. Accordingly, modified cut-offs from those proposed by the EWGSOP2 were used to define a larger group of subjects, not with sarcopenia itself, but with a low global "muscle function" [10]. The modified-cut offs were derived from our database that included 1437 patients who applied to our geriatrics outpatient clinic between November 2012 and November 2016. In this outpatient clinic, we evaluate all patients with comprehensive geriatric assessment, including handgrip strength and body composition analyses with BIA, provided that they give consent and have no acute problem or significant cognitive/medical problem that would interfere with assessment. The modified-cut offs were determined by applying the following formula; lowest sex-specific half of SMM index and lowest sex-specific half of muscle strength. In line with this formula, the modified cut-offs for SMM index and hang grip strength were as follows: muscle mass adjusted by height^2 for women: < 9.962 kg / m^2, for men: < 10.908 kg / m^2 and hand grip strength for women: < 22 kg, for men: < 34 kg. With this method, 59 subjects out of 100 participants were found to have low 'muscle function'. These 59 participants were assessed with the SF-36 and EQ-5D questionnaires in addition to the SarQoL-TR® questionnaires for the measurement of construct validity. After a 2-week interval, the participants were invited to the center once more and asked to fill in the SarQoL-TR® questionnaire for the evaluation of test–retest reliability.

(a) *Construct validity:* In accordance with the previously published SarQoL® validation studies, we used the SF-36 and EQ5D having similar and also different dimensions required to assess convergent and divergent validity, respectively. Since data obtained via SF-36 and EQ5-D were not normally distributed, we used Spearman's correlations to assess correlation between the total SarQoL-TR® score and these tests.

The SF-36 consists of 36 items to measure health-related QoL in 8 domains (physical functioning, role limitations due to physical health, role limitations due to emotional problems, pain, vitality, emotional wellbeing, social functioning, and general health). The total score for SF-36 ranges between 0/worst QoL to 100/best QoL [34, 35].

The EQ-5D records the level of self-reported problems on each of five domains: mobility, self-care, usual activities, pain, anxiety/depression. Each dimension is assessed using a three-point Likert scale as no problems, some problems or severe problems [36, 37].

(b) *Test–retest reliability:* The test–retest reliability was assessed by the intraclass coefficient correlation (ICC) between the first and second scores of the total SarQoL-TR® questionnaire and the individual domains through the questionnaire filled after a 2-week interval. An ICC over 0.7 was considered an acceptable reliability. The participants were questioned about having any change in their general health (physical and mental) over the 2-week period. The participants were not involved in the analysis if they had any health change over that 2-week interval.

Results

Translation and cultural adaptation

In the first stage, the SarQoL® questionnaire was translated into Turkish without major difficulties by two bilingual translators. In the second stage, the synthesis of these 2 translations (version 1) was made. In the third stage, back translation was made by two bilingual translators. In the fourth stage, an expert committee reviewed to compare the backward translations with the original English questionnaire. At the cultural adaptation stage, some important points have arisen due to some cultural differences between the western and eastern populations. For example, instead of do-it-yourself (DIY) inquiry, inquiry for maintenance and setting up works were considered; instead of attending senior citizen clubs and playing bridge, joining social activities (such as coffee house, club, association) and playing card games were considered regarding the cultural habit differences between the populations. After approval of these adaptations by the creators of the SarQoL® questionnaire, 'version 2' has been formed. Finally, at pretest stage, there was no need for any change and the SarQoL®-TR has been set.

Study population

A total of 300 older adults aged 60–99 years, who attended geriatric outpatient clinics at two different university hospitals between May 2017 and May 2019, were offered to complete the SarQoL-TR®. Among them, 95 older adults refused to give informed consent; 18 had acute problems; 35 had conditions that would preclude assessment with

BIA, i.e., edema, immobilization, implantable pacemaker; 11 patients had reasons for low muscle strength other than sarcopenia, e.g., stroke, peripheral vascular disorders, significant hand osteoarthritis; 36 had depression or dementia, 5 had hearing, sensory problems. Therefore, the validation analyses were performed in 100 older adults. The mean age was 74.7 ± 6.1 years, and 71% of the patients were female. The characteristics of the study population are shown in Table 1.

Psychometric validation analyses

1) In the first phase, discriminative power, internal consistency, and floor and ceiling effects were assessed.

(a) *Discriminative power:* 27 subjects were diagnosed with probable sarcopenia and 73 were without sarcopenia according to the EWGSOP2 criteria. Subjects with probable sarcopenia had higher total scores compared to non-sarcopenic subjects (50 ± 16 vs. 68.9 ± 16.9, $p < 0.001$). The scores of the physical and mental health, locomotion, body composition, functionality, activities of daily living and fears domains were significantly lower in sarcopenic subjects compared to non-sarcopenic ones (Table 2).

(b) *Internal consistency:* The Cronbach's alpha value of 0.88 was found indicating a high degree internal consistency. Deletion of a domain at a time led to Cronbach's alpha values ranging between 0.84 (for the domain 2 ''locomotion'') and 0.90 (for the domain 6 ''leisure activities''). All domains showed a significant positive correlation with the total score of the SarQoL® ranging from $r = 0.28$ (for the domain 6 "leisure activities") to 0.92 (for the domain 4 "functionality") (Table 3).

(c) *Floor and ceiling effects:* None of the subjects obtained the highest or lowest score on the questionnaire, and also the participants' scores did not cluster towards the

Table 1 Characteristics of the study population ($n = 100$)

Variables	All ($n = 100$)	Women ($n = 71$)	Men ($n = 29$)	p-value
Age (years)*	74.7 ± 6.1	74.1 ± 5.7	76 ± 6.9	0.146
BMI (kg/m^2)*	28.7 ± 5.4	29.9 ± 5.5	25.8 ± 3.9	< 0.001
SMM (kg)*	24.3 ± 3.7	23.0 ± 2.9	27.7 ± 3.5	< 0.001
SMMI (kg/m^2)*	10.1 ± 1.2	9.9 ± 1.2	10.3 ± 1.1	0.13
Gait speed (m/s)*	0.8 ± 0.27	0.8 ± 0.3	0.9 ± 0.3	0.081
Hand grip strength (kg)*	23.1 ± 8.7	19.5 ± 5.8	31.8 ± 8.7	< 0.001
Probable sarcopenia #πγ	27 (27%)	19 (26.8%)	8 (27.6%)	0.933
Confirmed sarcopenia #πγ	5 (5%)	2 (2.8%)	3 (10.3%)	0.145
Severe sarcopenia #πγ	4 (4%)	2 (2.8%)	2 (6.9%)	0.577

BMI body mass index, *SMM* skeletal muscle mass, *SMMI* skeletal musle mass index

*Data are given as mean ± standard deviation

#Data are given as number (percent-%)

πCut-offs for muscle mass adjusted by height2 for women < 7.4 kg / m^2, for men < 9.2 kg / m^2

γCut-offs for hand grip strength for women < 16 kg for men < 27 kg

Table 2 Discriminative power of the SarQoL®-TR

	Sarcopenia ($n = 27$)*	No sarcopenia ($n = 73$)	p-value
Probable sarcopenia			
Total score	50 ± 16	68.9 ± 16.9	< 0.001
D1 Physical and mental health	54.9 ± 19.8	73.9 ± 18.0	< 0.001
D2 Locomotion	41.1 ± 19.1	63.4 ± 23.5	< 0.001
D3 Body composition	61.9 ± 19.9	72.4 ± 17.9	0.02
D4 Functionality	59.7 ± 20.6	76.2 ± 17.1	< 0.001
D5 Activities of daily living	39.8 ± 19.1	63.5 ± 22.9	< 0.001
D6 Leisure activities	32.6 ± 20.9	38.9 ± 18.0	0.083
D7 Fears	80.1 ± 12.6	90.1 ± 10.0	< 0.001

*Sarcopenia was diagnosed according to EWGSOP2 probable sarcopenia definition provided that other reasons for low muscle strength, e.g., depression, stroke, balance disorders, peripheral vascular disorders were excluded

Table 3 Internal consistency and consruct validity analyses of SarQoL®-TR

	Total score of SarQoL®-TR, *r*	*p*-value
Internal consistency		
SarQoL® D1 Physical and mental health	0.84	< 0.001
SarQoL® D2 locomotion	0.85	< 0.001
SarQoL® D3 body composition	0.57	< 0.001
SarQoL® D4 Functionality	0.92	< 0.001
SarQoL® D5 Activities of daily living	0.90	< 0.001
SarQoL® D6 Leisure activities	0.28	0.030
SarQoL® D7 Fears	0.68	< 0.001
Convergent validity		
SF-36 Physical functioning	0.82	< 0.001
SF-36 Role limitation due to physical problems	0.69	< 0.001
SF-36 General health	0.60	< 0.001
SF-36 Vitality	0.69	< 0.001
EQ-5D Utility score	0.77	< 0.001
EQ-5D Mobility	− 0.59	< 0.001
EQ-5D Selfcare	− 0.59	< 0.001
EQ-5D Usual activities	− 0.63	< 0.001
Divergent validity		
SF-36 social functioning	0.50	< 0.001
SF-36 Role of limitation due to emotional problems	0.50	< 0.001
SF-36 Mental health	0.56	< 0.001
SF-36 Bodily pain	0.48	< 0.001
EQ-5D Pain/discomfort	− 0.56	< 0.001
EQ-5D Anxiety/depression	− 0.45	< 0.001

r: Spearman's correlation coefficients, *SF-36* short form 36, *EQ-5D* Euro quality-of-life-5 dimension, *SarQoL®-TR* sarcopenia and quality-of-life-Turkish

high or low end of the measure, indicating absence of floor and ceiling effects for SarQoL-TR®.

2) In the second phase, the construct validity and the test–retest reliability were determined. 59 subjects filled the questionnaire, but in two subjects, there were more than 20% missing data for SF-36 and EQ5D/EQ-VAS questionnaires. Therefore, analysis of the correlation between SF-36, EQ5D/EQ-VAS and SarQoL® was performed in 57 subjects. For test–retest reliability analyses, 49 subjects accepted the invitation to fill the questionnaire after a 2-week interval.

(a) *Construct validity:* Strong/good correlations were found between the total score of the SarQoL-TR® and some domains of the SF-36 which were supposed to have similar dimensions, such as physical functioning (r = 0.82, $p < 0.001$), vitality (r = 0.69, $p < 0.001$), role limitations due to physical problems (r = 0.69, $p < 0.001$), and general health (r = 0.60, $p < 0.001$). Strong/good correlations were also found between the total score of the SarQoL-TR® and some domains of the EQ-5D which were supposed to have similardimensions, such as mobility (r = − 0.59, $p < 0.001$), usual activities (− 0.63, $p < 0.001$), self-care (− 0.59, $p < 0.001$), and utility score (0.77, $p < 0.001$). We found weaker correlations between the total score of the SarQoL-TR® and some domains of the SF-36 questionnaire which were supposed to have different dimensions such as socialfunctioning (0.50, $p < 0.001$), role of limitation due to emotional problems (0.50, $p < 0.001$), mental health (0.56, $p < 0.001$) and bodily pain (0.48, $p < 0.001$). Weak correlations were also found between the total score of the SarQoL-TR® and some domains of the EQ-5D questionnaire which were supposed to have different dimensions, such as pain/discomfort (− 0.56, $p < 0.001$) and anxiety/depression (-0.45, $p < 0.001$) (Table 3).

(b) *Test–retest reliability:* For both the total score and the individual domains, very high ICCs were found revealing excellent agreement between the test and retest. For the SarQoL-TR® total score, ICC was 0.97 (95% CI: 0.94–0.98). For the individual domains, the lowest ICC was found for D7 (fears, ICC: 0.85) and the highest was for D5 (activities of daily living, ICC: 0.97) (Table 4).

Table 4 Test–retest reliability of the SarQoL®-TR questionnaire

	ICC	95% CI
Physical and mental health (D1)	0.89	0.81–0.94
Locomotion (D2)	0.96	0.92–0.98
Body composition (D3)	0.88	0.78–0.93
Functionality (D4)	0.96	0.93–0.98
Activities of daily living (D5)	0.97	0.95–0.99
Leisure activity (D6)	0.85	0.72–0.92
Fears (D7)	0.85	0.72–0.92
Total	0.97	0.94–0.98

SarQoL®-TR sarcopenia and quality-of-life-Turkish, *ICC* intraclass correlation coefficient, *CI* confidence interval

Discussion

In this study, we performed cross-cultural adaptation and validation of the Turkish version of the SarQoL® questionnaire, which stands as the only available tool to assess sarcopenia-specific QoL. Our results showed a high internal consistency, consistent construct validity and excellent test–retest reliability with no floor/ceiling effect. Therefore, the Turkish version of the SarQoL® was found to be a reliable and valid tool for the assessment of QoL of patients with sarcopenia.

At every stage of the study, both in the cultural adaptation and in the validation sections, we were in close contact with the creators of the questionnaire to compile the study in line with their suggestions and approvals. Turkish validation of the SarQoL® represents the most eastern validation study of the SarQoL® tool so far. There are substantial cultural differences between eastern and western populations (e.g., habits of DIY, playing bridge, attending senior citizens clubs are scarce in the eastern population and, therefore, have been replaced with alternative habits in the usual eastern life); therefore, translation and cultural adaptation phase was a very important section of this study. The application of the standardized validation protocol that includes a very comprehensive expert committee and the close and effective interaction with the creators of the tools enabled successful translation and cultural adaptation which would be challenging otherwise.

Since the consensus on the definition and diagnostic criteria for sarcopenia has not been reached yet, the EWGSOP criteria have been the most cited and applied criteria in sarcopenia researches [38]. The revised EWGSOP criteria (EWGSOP2) represent the most update consensus criteria for sarcopenia that have been recommended to be used both in researches and clinical practice by the EWGSOP group currently [1]. Hence, in this study, we applied the EWGSOP2 diagnostic criteria for the assessment of sarcopenia. This approach is in line with the most recent validation study of SarQoL® in Spanish [14]. The EWGSOP2 pointed out that since sarcopenia is associated with low muscle quantity and quality, their assessment has inherent problems, because they are technically difficult to measure accurately. The consensus noted that these parameters are being used mainly in research rather than in clinical practice. This acknowledgment brought the approach that, in diagnosing sarcopenia, low muscle strength overtook the role of LMM as a principal determinant. Accordingly, the consensus recommended that even if muscle mass/quality was not identified as low/impaired with the current techniques, individuals with low muscle strength should be regarded as having probable sarcopenia provided that other reasons for low muscle strength were excluded. Thereby, the EWGSOP2 recommended that probable sarcopenic individuals should be managed as sarcopenic patients in terms of assessment of its causes and starting intervention. In this study, we identified 27 subjects with probable sarcopenia but only 5 subjects with confirmed sarcopenia. The number of probable sarcopenic patients was comparable with the sarcopenic subjects studied in the English validation of the SarQoL® which was noted as 14 for discriminative power assessment. This approach is also in line with the study of the creators of the SarQoL® in which they signified that poorer QoL was more related to muscle function than to muscle mass [39]. According to the EWGSOP2 (probable sarcopenia) criteria, sarcopenic subjects had significantly higher total scores compared to non-sarcopenic subjects similar to that in the English, Romanian, Dutch, Polish, Greek, and Spanish validation studies of the SarQoL® [10–15]. The scores of all the domains of the SarQoL®, physical and mental health (D1), locomotion (D2), body composition (D3), functionality (D4), activities of daily living (D5), and fears (D7) were significantly lower in sarcopenic subjects than in non-sarcopenic subjects, except the leisure activities domain (D6). This can be explained by the fact that older adults in Turkey are often less involved in entertainment and outdoor activities. In the other validation studies of the SarQoL®, similar findings have been reported. In the Romanian version, sarcopenic individuals had significantly lower scores in all domains, except D4 and D6 (functionality and leisure activities) [11]. In the Polish version, sarcopenic individuals had significantly lower scores in all domains, except D4, D6 and D7 (functionality, leisure activities, fear) [13]. In the Spanish version, sarcopenic individuals had significantly lower scores in all domains, except D2 (locomotion) [14]. And in the English version, they had significantly lower scores in all domains, except D3, D6 and D7 (body composition, leisure activities, fear) [10].

The Turkish version of the SarQoL-TR® has also been shown to have a high internal consistency (Cronbach's alpha of 0.88), comparable with other validation studies with results ranging between 0.87 and 0.96) [10–15].

The construct validity analyses showed a strong and significant correlation with some domains of the SF-36 which have similar dimensions such as physical functioning, physical problems, vitality and general health. Moreover, we also found low correlations with divergent dimensions such as emotional problems, mental health, social functioning and bodily pain. We found a strong and significant correlation between total score of the SarQoL® and EQ-5D utility score. These correlations support the consistent construct validity of the Turkish version of the SarQoL®. The correlation coefficient *r* is interpreted as follows: values above 0.81 is considered excellent, 0.61–0.80 as very good, 0.41–0.60 as good, 0.21–0.40 as acceptable and, less than 0.20 as insufficient. However, in the English validation study, *r* values between 0.82 and 0.55 were expressed as strong/good correlation, for *r* values below this value expressed as weaker correlation. In the Dutch validation study, *r* values between 0.89 and 0.57 were expressed as strong/good and *r* values of 0.68–0.42 expressed as weak. Based on these studies, in our study *r* values with a magnitude of 0.59 or greater were considered as strong/good and *r* values with a magnitude of below 0.59 were considered as weaker correlations. Were all significantly correlated.

Finally, the test–retest reliability has been found to be excellent, both for the total score with an ICC score of 0.97 (95% CI 0.94–0.98) and the individual domains (ICC score ranging between 0.85 and 0.97). These results were comparable with other validation studies for the total score which had ICC scores ranging between 0.91 (95% CI 0.82–0.95) and 0.97 (95% CI = 0.95–0.99) [10–15].

This study has some limitations. First, in our sample, the number of sarcopenic patients was limited for these validation analyses. Therefore, we had to follow the method, which was used for the validation of the English version of the SarQoL® and this population does not reflect exactly a sarcopenic population. However, as outlined above, this approach is scientifically approved with the published English SarQoL® validation study and a large group of older adults' data were used to determine cut-offs for low global muscle function. Second, because we could not use dual X-ray absorptiometry (DXA), we assessed muscle mass by BIA which is less accurate than DXA. On the other hand, BIA has been considered a valid tool to estimate SMM and has the advantages of being portable, widely available, rapid, noninvasive, inexpensive and operator-friendly technique. In the Dutch and Greek versions of the SarQoL®, BIA was also the technique for muscle mass measurement. Additionally, use of BIA enabled us to use the total SMM index cut-off points for LMM for the Turkish population which was previously reported and recommended to be used in Turkish studies [27, 28]. Finally, one should consider that the longitudinal validity of the SarQoL-TR® is not known yet and needs to be investigated in future studies. Of note, a change of at least 7.35 points in overall QoL has been suggested as a true change, reflecting change in sarcopenia related QoL in a recent study and could be used in longitudinal validation studies of the SarQoL® [40].

In conclusion, this study confirmed that the Turkish version of the SarQoL® questionnaire is a valid, consistent and reliable tool for the assessment of QoL. It is ready for use in clinical practice and researches on sarcopenia. We hope and expect this validation to enable use of the SarQoL® tool in the eastern populations more confidently.

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Author contributions TE, GB, CB and OB designed the study. TE, GB prepared the first draft of the paper. Material preparation, data collection was performed by TE, SE, SA, PK, CK. MMO was responsible for statistical analysis of the data. All authors revised the paper critically for intellectual content and approved the final version. All authors agree to be accountable for the work and to ensure that any questions relating to the accuracy and integrity of the paper are investigated and properly resolved.

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Availability of data and material All data generated or analyzed during this study are included in this published article.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Statement of human and animal rights The study was conducted according to guidelines in the Declaration of Helsinki. The study was approved from the Istanbul University Ethics Committee (number: 2018/989).

Informed consent Written, informed consent was provided by all participants.

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