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Association between respiratory muscle strength with fall risk, fear of falling, and quality of life in sarcopenic older adults: a retrospective preliminary study

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ABSTRACT

Aims: Elderly patients with sarcopenia are known to have lower respiratory muscle strength compared to non-sarcopenics. The main aim of this study was to assess the relationship between maximal inspiratory and expiratory pressures with fall risk, fear of falling, and quality of life in sarcopenic elderly patients.

Methods: Twenty participants [12 women, 8 men; median (IQR) age: 81 (73-83.50)] who were diagnosed with sarcopenia enrolled in this retrospective study. Respiratory muscle strength assessment [maximum inspiratory and expiratory pressure (MIP and MEP, respectively)] with an electronic pressure measuring device; fall risk assessment with modified clinical test for sensory interaction and balance (m-CTSIB) under eyes open and closed on firm and foam surfaces; fear of falling with Falls Efficacy Scale International (FES-I), and quality of life with Sarcopenia Quality of Life Questionnaire (SarQoL) were performed for all participants. Spearman correlation analyses were used to determine the relationship between respiratory muscle strength with fall risk, fear of falling, and quality of life.

Results: Moderate positive association between SarQoL and MIP ($p=0.527$, $p=0.017$) and, SarQoL and MEP ($p=0.473$, $p=0.035$) was observed. On the other hand, there was no correlation between respiratory muscle strength with fall risk and fear of falling ($p>0.05$).

Conclusion: These results allow us to suggest that assessing respiratory muscle strength among sarcopenic older adults may assist physiotherapists to maintain appropriate rehabilitation strategies to improve quality of life.

Keywords: Respiratory muscle strength, sarcopenia, quality of life

INTRODUCTION

The proportion of the elderly population compared to the total population is increasing worldwide. While this rate was 8.3% in 2015, it is predicted to reach 17.8% by 2060.[1] The European Working Group on Sarcopenia in Older People (EWGSOP) is defined sarcopenia as a syndrome characterized by a loss not only in muscle mass but also in muscle strength or physical performance, leading to functional capacity impairment, dependence, falls and fractures, decreased quality of life, hospitalization and, death. In order to make a diagnosis of sarcopenia, the current situation of the patient should be analyzed in terms of muscle mass, muscle strength, and physical performance.[2]

Fear of falling is a common problem in countries with a fast aging population and is associated with poor quality of life and falls, but it is also common in those without falls.[3] In older people who have experienced falls, previous studies have confirmed that quality of life and physical function deteriorate because of fear.[4] It was reported that sarcopenia induces a reduction in functional capacity, activities of daily living, and quality of life[5] and increases the risk of falling.[6,7] In addition, it was found that the frequency of falls in sarcopenic people was higher than in non-sarcopenics.[8]

The respiratory system may exhibit reduced functional capacity during the aging process. This may negatively

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affect the ability to perform physical activity and exercise[5] or activities of daily living and also affect the quality of life.[9] The diaphragm, the main inspiratory muscle, acts in a feed-forward manner in response to rapid limb movements, stabilizes the spinal column and contributes to postural control.[10] It has been reported that, like the other muscles, the diaphragm can degenerate and lose its function throughout sarcopenia.[11,12] Therefore, reduced inspiratory muscle strength can deteriorate postural balance and increase fall risk.[6] Sarcopenic elderly patients had lower inspiratory muscle strength (MIP) and expiratory muscle strength (MEP) values when compared to non-sarcopenics.[13,14]

It has been found that MIP was positively correlated with skeletal muscle mass index[15], hand grip strength, and gait speed[15,16], and MEP was positively correlated with hand grip strength [12,16] in sarcopenic elderly individuals. Although the association between respiratory muscle strength and skeletal muscle mass index, hand grip strength, and gait speed has previously been studied in sarcopenia, little information is available concerning the association between respiratory muscle strength and fall risk, fear of falling, and quality of life. This present study aimed to investigate the relationship between respiratory muscle strength with fall risk, fear of falling, and quality of life among sarcopenic older adults.

METHODS

Participants

Twenty participants with sarcopenia who were diagnosed by the relevant physician in Gazi University Faculty of Medicine, Department of Internal Medicine, Geriatrics Division Outpatient Clinic between March 2023 and October 2024 were enrolled in this study approved by Gazi University Rectorate Ethics Committee (Date: 22.11.2022, Decision No: 2022-19/12.12.2022). All participants included in the study have read and signed the written informed consent form prior to assessment according to the principles of the Declaration of Helsinki. The rights of participants were fully protected during the study. The inclusion criteria were (a) scoring above twenty-one on the Mini-Mental State Scale and (b) volunteering to participate in the study; the exclusion criteria were (a) being an active smoker or quitting smoking in less than five years, (b) having undergone abdominal, thoracic or lower extremity surgery, (c) having a fracture within the last year, (d) having a disease such as pulmonary artery hypertension, glaucoma, an aneurysm that prevents the Valsalva manoeuvre, (e) having hypertension that cannot be controlled with antihypertensive medication, (f) having a neurological disease that affects mobility (g) having a chronic inflammatory disease that affects muscle metabolism, including uncontrolled diabetes (HbA1c>9) and rheumatoid arthritis, (h) having any acute and/or chronic cardiovascular and/or pulmonary disease, and (i) having a history of cancer.

Outcome Measures

Participant Assessment Form: In addition to the socio-demographic characteristics of the participants [age (years), weight (kg), height (cm), body-mass index (kg/m^2), gender, marital and educational status], whether they use the assistive device, chronic diseases diagnosed in the past; smoking and alcohol use; the presence of nutritional support and if they have fallen in the last year was collected.

Sarcopenia definition: Diagnostic algorithm was applied to define sarcopenia based on muscle mass, muscle strength, and physical performance. For the muscle strength assessment, hand grip strength was measured three times in the dominant hand using a digital handheld dynamometer (T.K.K.5401; Takei Scientific Instruments, Tokyo, Japan) while the participants were standing and their arms at a position parallel to the floor. The highest of the three repeated measurements was used in the analysis. Grip strength for females <16 kg and for males <27 kg were taken as cut-off points to assess muscle strength in the definition of sarcopenia.[2] For the muscle mass assessment, ultrasound with a linear probe at 9-12 MHz frequency (LOGIQ 5; General Electric, Northville, MI) was used to evaluate anterior thigh thickness/body mass index (STAR index). Muscle mass for females <1 and males <1.4 were considered as low.[17]Additionally, low physical performance was defined as gait speed ≤0.8 m/s during a 4-m walking test using a manual stopwatch.[2]

Respiratory muscle strength: Maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) was used to assess respiratory muscle strength.[18] Standard guidelines set by the American Thoracic Society/European Respiratory Society were followed during the assessment. Measurements were performed with a mobile and easy-to-use electronic pressure measuring device (MicroRPM, Vyaire Medical, Mettawa, IL) while the participant was sitting on a chair, using a mouthpiece placed in the mouth to prevent air leakage from the mouth and a clip on the nose from preventing nasal air leakage. The test-retest reliability of maximum mouth pressure measurements with the MicroRPM, intraclass correlation coefficient (ICC) was reported to be between 0.86 and 0.90 for a healthy population.[19] For hygiene precautions, each participant was given a mouthpiece. For the MIP assessment, the participant was asked to perform a maximal expiration manoeuvre followed by maximal inspiration for 1-3 seconds (Müller manoeuvre). For the MEP assessment, the participant first performed a maximum inspiration manoeuvre, followed by maximum expiration for 1-3 seconds (Valsalva manoeuvre).[20] Between each test, the difference between the two highest values of three to five acceptable maneuvers is ≤10%, with an interval of one minute provided that the best measurement result was obtained.[21] MIP and MEP values were calculated as the percentage (%) of expected values according to age and gender variables using Evans and Whitelaw's[22] reference equations. These reference values are 'MIP=108-(0.61xage) and MEP=131-(0.86xage)' in females, and 'MIP=120-(0.41xage) and MEP=174-(0.83xage)' in males.

Fall risk: The fall risk was determined via the modified clinical test for sensory interaction and balance (m-CTSIB) using the Biodex Balance System® (Biodex Medical Systems, Inc., NY). The m-CTSIB is designed to test the sensory selection process by compromising available somatosensory, visual, and vestibular senses while measuring the ability to minimize postural sway. The test consists of four different testing conditions while the participants stand at the center of the balance system platform with their feet shoulder width apart: a) eyes open firm surface; b) eyes closed firm surface; c) eyes open foam surface and; d) eyes closed foam surface. A sway index score is objectively calculated by the balance platform for each test condition. The sway index score is a measurement of the average sway movement from the

center position, ranging from 0 (no movement) to 4 (extreme movement), with higher sway index scores indicating a greater degree of instability and increased risk of falling.[23]

Fear of falling: Falls Efficacy Scale International (FES-I) developed by Yardley et al.[24] to assess the fear of falling, how confident older people are in their activities of daily living and indicates the level of fall concerns. The scale consists of 16 items, each rated on a 4-point scale. The total score range is from 16 (no worry about falling) to 64 (extreme worry about falling).[25] A score between 16-19 indicates a 'low fear of falling'; a score between 20-27 indicates a 'moderate fear of falling'; a score between 28-64 indicates a 'high fear of falling'.[26] Cronbach's α of the Turkish FES-I was 0.94 and the individual item ICC ranged from 0.97 to 0.99.[25]

Quality of life: Sarcopenia Quality of Life Questionnaire (SarQoL) was used to evaluate the quality of life. The questionnaire was developed by Beaudart et al. (2015) and consists of 22 questions with 55 items. It comprises seven sub-parameters, including 'physical and mental health, movement, body composition, functionality, activities of daily living, leisure time activities and, fears'. The total score ranges from 0 (worst health) to 100 (best health),[27] but there is still no cut-off score to define a low quality of life[28]. The Turkish version of the ICC was reported as 0.97, with high internal consistency (Cronbach's alpha: 0.88).[29]

Statistical Analysis

The normal distribution of the variables, to determine whether to carry out parametric or non-parametric tests, was analysed using the Shapiro-Wilk test. Quantitative variables were analysed using descriptive statistics [median (interquartile range-IQR)]. Frequencies (n) and percentages (%) were used to describe the qualitative variables. Spearman correlation analysis was used to evaluate the relationship between quantitative variables (coefficient of <0.1 negligible correlation; 0.1-0.39 weak correlation; 0.4-0.69 moderate correlation; 0.7-0.89 strong correlation and ≥0.9 very strong correlation).[30] Significance was set at p≤0.05. All statistical analyses were performed using IBM SPSS Statistics 26.0 software (IBM Japan Corp., Tokyo, Japan).

RESULTS

The demographic and clinical characteristics of the participants are presented in Table 1. None of the participants used alcohol or were smoking.

Results of respiratory muscle strength (MIP-MEP), fall risk (m-CTSIB sway index), fear of falling (FES-I), and quality of life (SarQoL) scores are given in Table 2. All MIP and MEP values were less than the expected values (n=20). The Highest Sway Index in fall risk assessment tests was the highest degree of difficulty (eyes closed on foam surface). Fear of falling was at a moderate level. The quality of life score was neither low nor high, but average.

Correlations between parameters are seen in Table 3. We observed a moderate positive association between SarQoL and MIP (p=0.527, p=0.017) and SarQoL and MEP (p=0.473, p=0.035). There was no statistical correlation between m-CTSIB Sway Index and FES-I scores with respiratory muscle strength.

Table 1. Characteristics of the participants (n=20)

Variable		Median (IQR=25-75%)
Age (years)		81 (73-83.5)
Weight (kg)		70.50 (60-78.50)
Height (cm)		160 (153.50-171)
BMI (kg/m²)		27.08 (23.59-30.48)
		n (%)
Gender	Female	12 (60)
	Male	8 (40)
Marital status	Married	20 (100)
Educational status	Undergraduate	14 (70)
	Postgraduate	6 (30)
Using assistive device	Yes	8 (40)
	No	12 (60)
Other chronic diseases	Yes	16 (80)
	No	4 (20)
Nutritional support	Yes	5 (25)
	No	15 (75)
Falls in the last year	Yes	7 (35)
	No	13 (65)
Fear of falling	Low	5 (25)
	Modarate	10 (50)
	High	5 (25)

Quantitative variables were analysed using descriptive statistics [median (interquartile range-IQR)]. Frequencies (n) and percentages (%) were used to describe the qualitative variables. BMI: Body-mass index, IQR: Interquartile range

Table 2. Outcome measures of the participants (n=20)

Variables		Median (IQR=25-75%)
Respiratory muscle strength	MIP (cmH_2O)	43 (31-61)
	MIP (%)	65 (59.59-85.97)
	MEP (cmH_2O)	50.50 (39-76.50)
	MEP (%)	70.37 (61.34-105.11)
Fall risk (0-4)	m-CTSIB Sway Index Score: eyes open on firm surface	0.61 (0.43-1.07)
	m-CTSIB Sway Index Score: eyes closed on firm surface	0.93 (0.73-1.30)
	m-CTSIB Sway Index Score: eyes open on foam surface	1.28 (0.98-2.68)
	m-CTSIB Sway Index Score: eyes closed on foam surface	3.80 (2.16- 4)
Fear of falling (16-64)	FES-I	24 (19-27)
Quality of life (0-100)	SarQoL	53.22 (44.86-62.53)

Quantitative variables were analysed using descriptive statistics [median (interquartile range-IQR)]. MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure, m-CTSIB: Modified clinical test for sensory interaction and balance, FES-I: Falls Efficacy Scale International-I, SarQoL: Sarcopenia Quality of Life Questionnaire, IQR: Interquartile range

Table 3. Correlation coefficient (p) and p-value between respiratory muscle strength with, fear of falling, fall risk, and quality of life (n=20)

			Respiratory muscle strength	
			MIP	MEP
m-CTSIB Sway Index Score	Eyes open on firm surface	p	-0.382	-0.314
		p-value	0.097	0.177
	Eyes closed on firm surface	p	-0.172	-0.037
		p-value	0.469	0.877
	Eyes open on foam surface	p	-0.031	0.028
		p-value	0.897	0.906
	Eyes closed on foam surface	p	-0.055	-0.035
		p-value	0.817	0.882
FES-I	Fear of falling	p	-0.207	0.050
		p-value	0.381	0.833
SarQoL	Quality of life	p	0.527	0.473
		p-value	0.017*	0.035*

Spearman correlation analysis was used to evaluate the relationship between quantitative variables. m-CTSIB: Modified clinical test for sensory interaction and balance, FES-I: Falls Efficacy Scale International-I, SarQoL: Sarcopenia Quality of Life Questionnaire, MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure, p-values ≤0.05 indicate statistically significant correlation

DISCUSSION

This study aimed to investigate the association between respiratory muscle strength with fall risk, fear of falling, and quality of life in sarcopenic older adults. Although the association between respiratory muscle strength and sarcopenia-related factors, including hand grip strength, gait speed, and skeletal muscle mass index, has been studied previously, to our knowledge, this is believed to be the first study to examine the association between respiratory muscle strength with fall risk, fear of falling, and quality of life in sarcopenic older adults. Our findings indicated that values of MIP and MEP in sarcopenic older adults are significantly associated with quality of life but not fall risk and fear of falling.

Age-related sarcopenia potentially reduces strength production.[31] One of the important physiological changes in the respiratory system that is accompanied by aging is the decline in respiratory muscle strength[32] due to geometric changes in the thoracic cage, the reduction of costo-vertebral joint mobility, the degradation of neuromuscular recruitment patterns, as well as the loss of muscle fiber-type.[34] Respiratory muscle strength declines at a rate of 8-15% per decade of life after 50 years of age.[21] Similarly, in our study, respiratory muscle strength was lower than the expected value according to age and gender reference equation.[22] Decline in muscle strength may affect the ability to perform activities of daily living and potentially affect quality of life.[9] This notion was also confirmed in our study with correlation analysis revealing a significant positive, albeit moderate, relationship between respiratory muscle strength and quality of life. Therefore, it could be expected that sarcopenic elderly with higher respiratory muscle strength can have better results in their quality of life.[5]

The m-CTSIB assesses how well individuals can use sensory information (vision, proprioception, and vestibular inputs) to maintain balance. This approach focuses on the nervous system's ability to process and integrate sensory signals for balance control.[34] In this study, the m-CTSIB test was used to assess the fall risk of the sarcopenic elderly. As expected, the worst score was in the test with the highest degree of difficulty (eyes closed on foam surface). However, m-CTSIB scores showed no significant correlation with MIP and MEP. Respiratory muscles, such as the diaphragm and intercostals, primarily facilitate breathing but can also contribute to trunk stability through intra-abdominal pressure modulation during dynamic tasks.[10] But under m-CTSIB conditions, the balance is challenged by sensory feedback rather than physical tasks that heavily recruit the respiratory muscles. For instance, in a study on respiratory muscle function and balance, the contribution of respiratory muscle strength to static balance was minimal compared to its role in dynamic or high-intensity tasks.[35] Thus, the lack of a significant relationship between m-CTSIB outcomes and respiratory muscle strength can be attributed to the sensory-based m-CTSIB, which does not demand substantial physical engagement from the respiratory muscles. One of the studies in the literature has shown that single-leg standing time could be more accurate in predicting fall risk, especially for the falling elderly who could not stand for over 10 seconds on a single leg.[36] Similar to the present study, Hyodo et al.[12] also did not find any correlation between single-leg standing time scores and respiratory muscle strength in sarcopenic group for fall risk assessment.

Fear of falling causes the patient to become more cautious and slower in all movements.[12] In this present study, fear of falling scores were at a moderate level, but these scores did not show any correlation with respiratory muscle strength values. It is possible that fear of falling is more directly influenced by the strength and function of lower-limb muscles[37] and psychological factors like anxiety and depression[38] rather than respiratory muscle strength. Additionally, a history of falling is a well-known risk factor for fear of falling, as persons who have experienced falls are more likely to develop fear.[3] However, 65% of the participants had never experienced a fall in our study. Similarly to our results, it has been reported that 50% of the elderly have not experienced fear of falling.[39] Larger studies should be conducted to determine the rate of fear of falling in elderly people with sarcopenia who have not fallen.

The strengths of this study are, first, to our knowledge, this is the first study to identify the relationship between respiratory muscle strength with fall risk, fear of falling, and quality of life in sarcopenic older adults. Clinically, our results could help physiotherapists to maintain appropriate respiratory muscle training strategies to improve the quality of life of sarcopenic older adults. Second, the recently published sarcopenia-specific tool -SarQoL- whose Turkish version was used to assess quality of life.

Limitations

There are also several limitations to the current study that should be acknowledged. One of the limitations is that this study was a preliminary study with a small sample size. A small sample size could lead to inconclusive results. Future studies should focus on a greater number of sarcopenic elderly may be necessary. Another limitation is that it was limited to a single group at a single facility, and there was no control group. Comparing all parameters in this study with a healthy elderly group without sarcopenia will make the study more valuable.

CONCLUSION

This study investigated the relationship between respiratory muscle strength and fall risk, fear of falling, and quality of life in sarcopenic older adults. These results suggest that the respiratory muscle strength of sarcopenic older adults is significantly correlated with quality of life but not with fall risk and fear of falling. Therefore, respiratory muscle strength among sarcopenic older adults may assist physiotherapists in maintaining appropriate rehabilitation strategies. However, the body of research into the effects of respiratory muscle training is inconclusive. This training may be beneficial in improving the quality of life of the sarcopenic elderly.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Gazi University Ethics Committee (Date: 12.12.2022, Decision No: 2022-19).

Informed Consent

All participants signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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