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Association between gait speed and muscle mass and strength in postmenopausal women

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Abstract

Background: Gait speed (GS) is the most popular tool used in clinical practice to diagnose functional performance. In order to maintain the independence of the elderly, it is useful to determine the association between gait speed and skeletal muscle mass, as well as the strength of the lower and upper extremities, which was the aim of this study. Material and methods: The study involved 95 women in the postmenopausal period. The skeletal muscle mass (SM) was determined using a bioelectric impedance method using an octapolar bioimpedance InBody 720 analyzer. Upper limb strength was measured using the handgrip strength (HS) and arm curl (SAC) tests. The strength of the lower extremities was tested using a 30-second chair stand (SCS) test and the speed was based on the GS test. Results: A significant correlation between the GS test results and the strength of the lower extremities ($r = 0.23$; $p = 0.03$) was demonstrated. There was no correlation between GS and the strength of the upper extremities, muscle mass & the skeletal muscle mass index (SMI). Conclusions: Our observations can be useful for instructors and trainers in the process of programming physical activity of older women and in diagnostics of sarcopenia.

Keywords

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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INTRODUCTION

The increasing number of people over 60 in the European population poses a challenge for modern science in the field of elderly health protection [1–5]. One of the current topics, meeting the need to improve the quality of life of elderly people, is the promotion of female physical activity in the postmenopausal period. In medical terminology, postmenopause is a period in a woman's life that usually starts 12 months after the last menstrual period [6]. The postmenopausal period is associated with changes in the body composition that may lead to sarcopenia [7]. According to the European Working Group on Sarcopenia in Older People (EWGSOP), sarcopenia is a syndrome characterized by a gradual and generalized loss of weight and strength of skeletal muscles with a risk of complications such as physical disability, leading to reduced quality of life and death [8]. Sarcopenia is also associated with mobility disorders, a higher risk of falls and bone fractures, impaired ability to perform daily self-care activities and loss of functional independence [9]. Diagnosis of sarcopenia is usually based on quantitative determination of skeletal muscle mass and contraction strength, as well as the evaluation of physical fitness. For this purpose, EWGSOP recommends the use of 3 diagnostic criteria: determination of the skeletal muscle mass index, assessment of the strength using the handgrip strength test, as well as the assessment of gait speed using the GS test [8]. The GS test is the most popular tool used in clinical practice and in sarcopenia for diagnosing functional efficiency [10]. The results of the GS test allow predicting the occurrence of health problems in well-functioning elderly people (M = 74.2 years) [11], the functional dependence of people over 65 years of age during basic everyday life activities [12], falls and fractures [13,14], cognitive functions [15], hospitalization [11], and the risk of death and developing disability [16].

Locomotion is a feature of human evolution, and the speed of gait provides man with evolutionary, medical, cognitive and health benefits throughout the entire life [17]. Understanding the factors, including strength and muscle mass, that underlie the evolution of free gait is therefore clinically important [18]. Studies on the relationship between gait speed and muscle strength and mass have been undertaken in only few publications, but their results are still ambiguous. Some studies report that the strength of lower limb extensor muscles, as determined in functional tests, shows a significant positive correlation with walking speed in hospitalized men (M = 88.5 ±6 years) and women (M = 86.5 ±6 years) [19]. Other publications show that there is no significant correlation between muscle mass and walking speed in older people in the local community [18]. However, recent studies have not confirmed the relationship between the strength of lower limb muscles and walking speed in the GS test [20], which needs to be clarified in further studies.

During the analysis of literature, limitations in studies documenting the relationship between GS and the strength of upper extremities in postmenopausal women were also observed, which needs to be addressed. Meanwhile, muscle strength as measured by the HS test is, as already mentioned, one of the three diagnostic criteria for sarcopenia. This test has been repeatedly used in scientific research, especially as an indicator of the overall muscle strength and the health status in elderly people [21].

Problems indicated in the introduction and ambiguous results of the conducted studies confirm that the study problem addressed in this paper is current and requires detailed elaboration. The aim of the study was to determine the association between gait speed and skeletal muscle mass level, as well as the strength of lower and upper extremities.

MATERIAL AND METHODS

CHARACTERISTICS OF THE TEST GROUP

A total of 95 women between 62 and 81 years of age (M = 68.76 years; ±5.02) participated in the study. Participants of the study were selected from a group of 248 women who completed the questionnaire. Recruitment of women was conducted at the Universities of the Third Age in Gdańsk and Sopot and at selected medical centers in Gdańsk. The criterion for inclusion in the study was postmenopausal age, i.e. women who had had no menstruation for at least 12 months and no contraindications to physical fitness tests.

Each participant in the project agreed in writing to participate in the study. The study was approved by the Bioethics Commission of Regional Medical Chamber under process number KB-29/14. The characteristics of women, taking into account selected morphological components and physical fitness, are presented in the table below.

Table 1. Characteristics of selected morphological components and physical fitness of the studied women

Variables	M	Me	SD
BM [kg]	69.19	67.7	11.35
BMI [kg/m^2]	27.52	26.81	4.20
SM [kg]	23.05	22.93	2.65
SMI [kg/m^2]	9.16	9.22	0.76
GS [m/s]	1.69	1.66	0.23
PK HS [kg]	22.45	22.35	4.19
SAC [rep/s]	21.15	20.15	4.26
SCS [rep/s]	17.57	18	3.36

Notes: BM – body mass; BMI – body mass index; SM – skeletal muscle mass; SMI – skeletal muscle mass index; GS – gait speed; HS – handgrip strength; PK – peak; SAC – arm curl; SCS – chair stand.

SMI results show that there is no sarcopenia in the subjects. Average SMI values were higher than the threshold values – 7.12 kg/m^2 recommended for use in Poland as diagnostic criteria for the development of sarcopenia [22].

High Body Mass Index (BMI) values indicate that women were overweight and, therefore, in the group of people with a higher risk of developing diseases associated with overweight and obesity. A detailed health analysis (Table 2) confirmed that 39% of women had arterial hypertension. Moreover, 6% of subjects suffered from diabetes and 2% – from ischemic heart disease. It was also noted that 16% of women had osteoporosis, while 5% had rheumatoid arthritis. It was also found that 82.1% of subjects declared participation in physical activities.

Table 2. General characteristics of women's health by study groups

Diseases	n	%
Diabetes	6	6
Hypertension	37	39
Ischemic heart disease	2	2
Osteoporosis	15	16
Rheumatoid arthritis	5	5

Notes: n – number of women

Measurements of body composition and selected anthropometric parameters

Body mass (BM) and skeletal muscle mass (SM) were determined using the bioelectric impedance analysis (BIA) method using an octapolar bioimpedance InBody 720 analyzer. SMI is calculated based on the muscle mass/height^2 equation (kg/m^2), as recommended by the EWGSOP [8]. The height of the body (cm) has been determined with an accuracy of 0.1 cm. The BMI is defined by the following equation: body weight/height^2 (kg/m^2).

Physical fitness tests

The upper limb force was measured in the standing position using the handgrip strength test (HS). The measurement was carried out using a digital manual dynamometer (SAEHAN, Changwon, Korea). The test was repeated three times on the right and left hand with a 30 s interval between repetitions [7]. The analysis took into account the best result from 6 trials determining the maximum peak (PK) recorded in kilograms (kg). In order to determine the level of functional strength, two attempts with Fullerton physical fitness test for the elderly were used: 30-second chair stand (SCS) for lower limb strength and arm curl (SAC) for measuring upper limb strength [23].

The gait speed test (GS) was to pass a distance of 6 meters as quickly as possible. The measurement was carried out with a stopwatch and the speed was determined in (m/s). The test was repeated three times. The analysis took the best result into account [10]. The conducted tests demonstrated a strong correlation between the results obtained in GS and the Short Physical Performance Battery values [24].

Diagnostic survey

For the purpose of recruitment and characteristics of the test subjects, a diagnostic survey was conducted with the use of author’s own questionnaire. The questions concerned the subjective assessment of health condition and physical activity of the subjects, and information on the occurrence of the last menstruation.

Statistical analysis

To describe the basic position and dispersion of the measurement results within the individual variables, we used mathematical quantities: mean (M), median (Me) and standard deviation (SD). Distribution of normal characteristics was verified via the Shapiro-Wilk test. Examination of the relationship between the selected variables was performed using the Pearson correlation analysis. The correlation coefficient was marked with the letter "r", and the probability of the test as "p" [25].

RESULTS

The results of the correlation between GS and muscle mass & strength are presented in Table 3 and Figure 1.

Table 3. Relationship between GS and muscle mass & strength in postmenopausal women

Variables	r	p
GS[m/s] vs SM [kg]	0.21	0.054
GS[m/s] vs SMI [kg/m2]	0.11	0.92
GS[m/s] vs PK HG [kg]	0.18	0.12
GS[m/s] vs SCS [rep/s]	0.23	0.03*
GS[m/s] vs SAC [rep/s]	0.19	0.08

*Notes: SM – skeletal muscle mass; SMI – skeletal muscle mass index; GS – gait speed; HS – handgrip strength; PK – peak; SAC – arm curl; SCS – chair stand; r – correlation coefficient; p – level of significance; *statistical significance, p < 0.05.*

The analysis of the test results showed a statistically significant positive correlation (r = 0.23; p = 0.03) between GS and the functional strength of the lower extremities (Fig. 1). Our observations can be useful for instructors and trainers in the process of programming physical activity of older women.

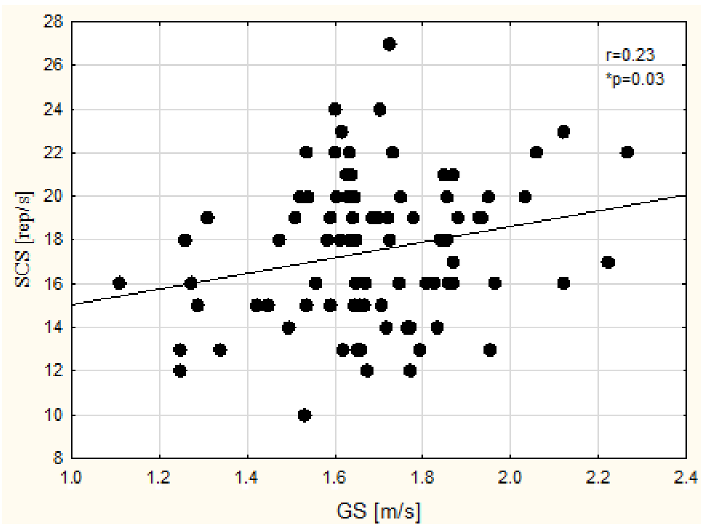

Fig. 1. Relationship between GS and functional strength of lower extremities in women

*Notes: GS – gait speed; SCS – chair stand, r – correlation coefficient; p – level of significance; *statistical significance, p < 0.05.*

At the same time, there was no significant relationship between GS and upper extremity muscle mass & strength (Fig. 2). However, it was noted that in all the analyzed variables, the direction of the relationship was positive. The strongest association was recorded between GS and SM (r = 0.21; p = 0.054), as well as between GS and the strength of the upper extremities: GS vs SAC (r = 0.19; p = 0.08) and GS vs PK HG (r = 0.18; p = 0.12). The weakest association was found between GS and SMI (r = 0.11; p = 0.92).

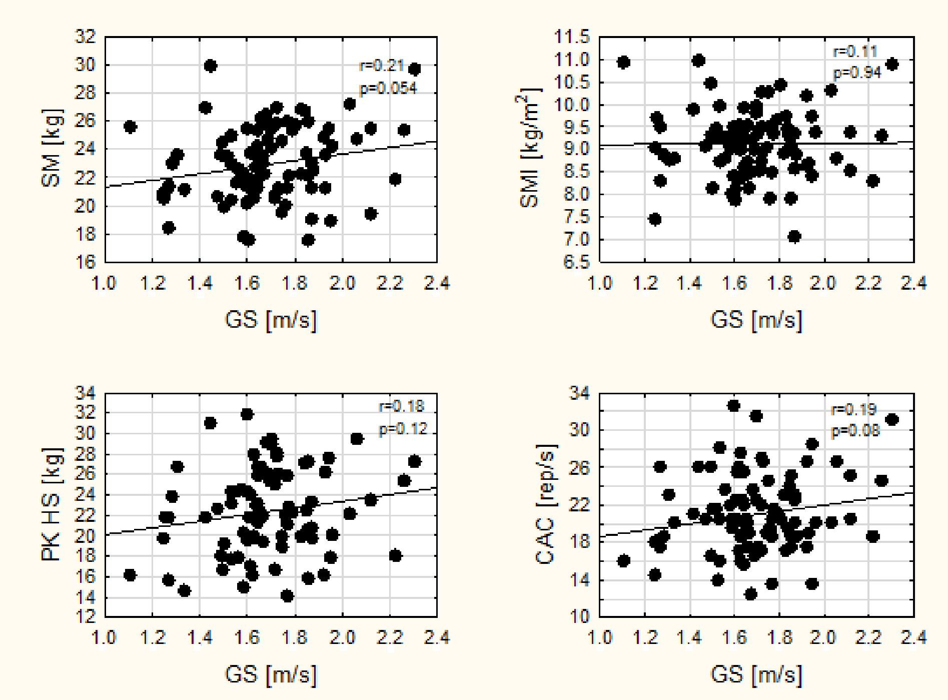

Fig. 2. Relationship between GS and muscle mass & the strength of the upper extremities in women

*Notes: SM – skeletal muscle mass; SMI – skeletal muscle mass index; GS – gait speed; HS – handgrip strength; PK – peak; SAC – arm curl; r – correlation coefficient; p – level of significance; *statistical significance, p<0.05.*

DISCUSSION

The study showed an important relationship between the GS test results and the strength of the lower limbs, measured in the chair stand test (r = 0.23; p = 0.03). At the same time, there was no correlation between GS and the strength of upper extremities, SM & SMI.

Our findings on the relationship between lower limb muscle strength and gait speed were consistent with those of other authors. Findings of Hayashida et al. [18] proved that the strength of knee extensor muscles was significantly positively correlated with the maximum GS in the group of women and men over 65 years of age. Comparing the results, however, it should be noted that these researchers used a hand-held dynamometer to assess strength, while we used the chair stand test to measure the functional force of the lower extremities. Studies carried out by Hughes et al. [26] explain, however, that older people use up to 97% of their knee extensors when getting up from the chair, which explains the similarity in the results. Similar observations were made by Rybertt et al. [27]. Over the course of the study, the authors stated that normal and maximum gait speeds in elderly people are influenced mainly by the strength of lower limb muscles and aerobic efficiency.

Nevertheless, Muehlbauer et al. [20] obtained slightly different results. The authors argue that the normal gait speed was only related to the strength of the hip joint extensors (r = 0.29, p = 0.015), while the strength of the muscles bending the sole of the foot was related to the maximum gait speed and the length of the step (both r = 0.40, p = 0.003). Researchers point out, however, that the study had certain limitations which could influence its results. Firstly, healthy people (M = 70.1 years; ±3.8) of both sexes with high physical activity were examined. Therefore, the selected group was not representative, which makes it impossible to generalize the results to include the entire population of older people. Secondly, a small number of elderly people (n = 20) participated in the study, which increases the likelihood of underestimation of the study results.

Further analysis showed that GS was not related to the functional strength of the upper extremities. A study by Ferrucci et al. [28] explains, however, that the loss of muscle mass is greater in the lower extremities than in the upper ones. These differences are partly explained by a decrease in physical activity in the group of elderly people, and thus a decrease in the involvement of lower limb muscles. Probably because of the differences in the upper and lower extremity strength loss, they are differently related to the gait speed.

During the study we also observed that muscle mass, in contrast to the strength of the lower extremities was not correlated with GS. Interpretation of the obtained results is facilitated by observations of other authors, who report that the decrease in muscle mass is accompanied by a higher decrease in strength and power starting from the age of 35 [28, 29]. Recent evidence, however, questions this relationship by indicating that the preserved SM or the increase in SM did not prevent an age-related decrease in muscle strength [30, 31]. In view of the foregoing reports, it may be thought that strength and mass may also show differences in relation to GS.

Our recent analysis has also shown that there is no significant association between GS and SMI, which is the main diagnostic criterion of sarcopenia. The obtained result is very important, as it suggests that both the GS test measurement and the SMI level assessment shall be used independently to identify people at risk of sarcopenia. On the other hand, a recent study including three groups (EG1, EG2, CG) of women in the postmenopausal period did not show a relationship between SMI and the strength measured by the HS test (respectively $r1 = 0.39$, $p1 = 0.06$; $r2 = 0.12$, $p2 = 0.58$; $r3 = 0.23$ $p3 = 0.28$). This relationship also did not undergo modification under the influence of health training [7].

There were some limitations in this study. Firstly, the evaluation of muscle strength was done mainly with the use of functional tests, which makes it difficult to determine the precise proportion of individual muscles during the tests. Secondly, the vast majority of the studied women (82.1%) declared participation in physical activities. A small proportion of inactive persons in the study may have influenced the obtained results. Thirdly, our study did not demonstrate sarcopenia incidence in the women. These limitations may have contributed to the underestimation of the study results.

CONCLUSIONS

There was a statistically significant positive correlation demonstrated between gait speed and the functional strength of the lower extremities. There was no correlation between GS test results and the strength of upper extremities, SM and SMI. Taking into account the limitations of the conducted study, the described topic requires further studies with participation of people with sarcopenia.

Our observations can be useful for instructors and trainers in the process of programming physical activity of older women and diagnostics of sarcopenia.

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