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New insights on the link between body composition, nutritional status and physical performance in elderly outpatients

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Abstract: Objectives: The aim of the study was to assess the relationship between body composition, nutritional status and physical ability in elderly outpatients.
Method:. In this cross-sectional study, demographic data and medical history were collected from patients aged ≥60 years followed in the Geriatric Outpatient Clinic from October 2010 to February 2014. Body composition was examined using a dual-energy X-ray absorptiometry. Physical performance was assessed by gait speed (GS), Timed Up & Go Test (TUG), Six Minute Walk Test (6MWT). The nutritional status was evaluated using the Mini Nutritional Assessment (MNA) and serum albumin level.
Results: Mean age (± SD) of 76 patients (64.47% men) was 71.93 ± 8.88 yrs.
The most common diseases were: hypertension (89.47%), coronary heart disease (81.58%) and chronic heart failure (68.4%). In multiple regression analyses, the factors significantly affecting GS were: age ($B = -0.017$, $p \leq 0.0001$), good nutritional status ($B = 0.038$, $p < 0.01$) and percent of lower extremity fat ($B = -0.009$, $p < 0.05$). Longer TUG time was associated with poorer nutritional status ($B = -0.031$, $p < 0.01$), older age ($B = 0.01$, $p < 0.01$) and a higher number of comorbidities ($B = 0.034$, $p < 0.05$). 6MWT was influenced negatively by age ($B = -3.805$, $p < 0.01$) and percent of lower extremity fat ($B = -2.474$, $p < 0.05$).
Conclusions: Age and nutritional status remain a strong determinant of physical fitness deterioration. Different measures of physical performance are influenced by different elements of body composition — no single element of body composition was found determining the deterioration of all assessed parameters of physical fitness.
Identifying the relationship between body composition, nutritional status and physical performance can help elucidate the causes of disability and target preventive measures.

Keywords: aged, geriatric assessment, body composition, nutrition status, physical performance.

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Introduction

Malnutrition and poor physical performance are two highly prevalent conditions in older adults that are associated with poor health outcomes, such as higher morbidity, mortality, and lower quality of life [1]. Both conditions may be interrelated and may potentiate each other [1]. Poor nutritional status might affect the functional independence of older people [2]. Therefore, assessing the nutritional status of older people is of great importance.

One of the assessment methods of nutritional status recommended by The European Society for Clinical Nutrition and Metabolism (ESPEN) and Global Leadership Initiative on Malnutrition (GLIM) is body composition testing [3].

Changes in body composition are associated with aging, wherein loss of muscle and bone mass and increase in total fat mass occur. In general, there is a decrease in subcutaneous fat mass, while visceral fat, liver fat, and muscle fat infiltration tend to increase with age [4].

Analyzing in detail pathophysiological changes in body composition, the loss of muscle mass is accompanied by an accumulation of inter- and intra-muscular fat, bone marrow, adipose tissue which is hallmarks of osteoporosis and sarcopenia [5]. The three main components of body composition — muscle, fat and bone — are derived from multipotent mesenchymal cells. These cells further differentiate into myoblasts, osteoblasts, chondrocytes and adipocytes and have been shown to be related to each other [6]. It is well known that physical inactivity and ageing promotes sarcopenia and induces both, obesity and osteoporosis [6].

A decrease in muscle mass is usually accompanied by a decrease in bone mass and is often linked to nutritional deficits and reduced function in geriatric inpatients [7]. What is important, co-occurrence (osteosarcopenia) is associated with a higher degree of malnutrition than osteoporosis or sarcopenia alone [7]. Furthermore, individuals with osteosarcopenia are at increased risk of falling and fractures, decreased functional capacity and earlier death [8].

There are some conflicting results in the literature regarding the connection between body composition, physical ability and nutritional status. When assessing the relationship between muscle mass and physical fitness indicators such as walking speed or chair stand, some authors found the presence of such a relationship [9–11], while other studies did not confirm it [12–14] or confirmed the relationship with only some physical performance parameters [15] or in one of the sexes [9]. Similarly, the evaluation of the relationship between physical tests and the content of adipose tissue gave mixed results. Some studies demonstrated a correlation between body fat (most often percent of body fat) and gait speed [13, 16], or chair stand [17], whereas in the study by Waters *et al.* this relationship was found only in women [9]. These differences may be the result of the studied population (race, sex, age, comorbidities, specific groups of patients — sarcopenic [13], diabetic [17], with cardiovascular diseases [11]), and the method of body composition assessment (dual-energy X-ray absorptiometry — DXA, bioimpedance) and methods of physical performance assessment.

Owing to the presence of conflicting findings in the relationship between body composition, nutritional status and physical performance, the aim of this study was to assess the relationship between the components of body composition, the results of nutritional status and particular physical ability tests in populations of outpatient older adults.

Materials and Methods

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Bioethical Committee of Jagiellonian University (Krakow, Poland) and all individuals signed an informed consent to participate in the study. Study design, patient enrollment and methods were described elsewhere [18]. Briefly, inclusion criteria for this cross sectional study involved those individuals aged 60 years or older, included from October 2010 to February 2014, who could independently visit the Geriatric Outpatient Clinic and who did not meet the exclusion criteria (an active inflammatory state, a Mini Mental State Examination score below 10). These participants constituted a representative group of geriatric outpatients.

In all patients, demographic data, smoking status, past/current medical history were obtained using a structured questionnaire. Data obtained from questionnaires was supplemented with information from medical records. The following comorbidities (based on medical documentation) have been taken into account: coronary heart disease (CHD)/myocardial infarction, chronic heart failure (CHF), hypertension, valve defect, diabetes, stroke, osteoarthritis, falls. These comorbidities were the most typical of the study group.

Weight (kg) and height (m) were measured and Body Mass Index (BMI) (kg/m^2) was calculated.

Physical performance was assessed by means of gait speed (GS), Timed Up & Go Test (TUG) and Six Minute Walk Test (6MWT).

Gait speed was measured at the distance of 4 meters; the participants walked at their normal speed over the entire distance and two trials were measured to calculate the average gait speed.

Timed Up & Go Test was performed twice and average recorded time was the final score. Examinees sat in the chair with the arms resting comfortably but not on the armrests. The time was started to be recorded as they got up from the chair, and then walked three meters, turned around, returned to the chair, and sat down. While an assistive device was permitted, no other form of physical assistance was used. If the balance was impaired, we protected the patient to prevent from falling.

Six Minute Walk Test was performed once and the participant walked as far as possible for 6 minutes, walked back and forth in the hallway with cones at either end of the 30 meter stretch as turning points.

Muscle mass, including total lean body mass (LBM) and appendicular lean mass (ALM), and the distribution of adipose tissue was examined using a dual-energy X-ray absorptiometry (DXA) (Lunar Prodigy, General Electric Medical Systems).

In addition to this, to assess people's self-care activities we used Katz Index of Independence in Activities of Daily Living (ADL) [19]. To assess more complex activities necessary for functioning in community settings the Lawton's Instrumental Activities of Daily Living (IADL) Scale was also used [20].

Nutritional status was evaluated using the Mini Nutritional Assessment (MNA) [21] and serum albumin level. MNA score of 24 points and higher suggested normal nutritional status, 17–23.5 points suggested increased risk of malnutrition, and below 17 points suggested malnutrition [21]. MNA score was used as a continuous variable.

Statistical analysis

Distribution of variables was verified using the Shapiro–Wilk and Kolmogorov–Smirnov tests. Descriptive statistics include calculations of means and standard deviations (SD) for variables normally distributed, and median with interquartile range (IQR) for skewed distributed variables. Moreover, percentage distribution of qualitative data was presented. Spearman correlation analyses were performed to assess the relationships between GS, 6MWT, TUG amongst other clinical parameters.

Finally, stepwise regression models were performed to identify whether nutritional status and body composition parameters significantly and independently related with GS, 6MWT score, and TUG time (due to highly skewed distribution of TUG results, the variable after log-transformation was included to the regression model). The set of the independent variables were identified based on the results of correlation analyses and, from among the significant predictors, were selected to create the most optimal logistic regression models. Information on the composition of the specific regression models is presented in the results section.

P-value for inclusion and exclusion from the regressions model was set at <0.1. The Condition Index for the collinearity in regression models did not exceed 40.

The statistical analyses were carried out using SAS 9.3 (licensed to Jagiellonian University).

Results

Baseline characteristics

One hundred sixteen individuals participated in our study, yet due to a lack of data, the statistical analysis included 76 subjects, for whom all necessary data was available.

The mean age (± SD) of the examined patients was 71.93 ± 8.88 yrs (64.47% men). The number of medical comorbidities, expressed as median [IQR] was 6.0 [IQR, 4.0–7.0]. It is worth emphasizing that chronic heart failure (CHD) was diagnosed in 68.4% of the participants, nevertheless the most common were hypertension (89.47%) followed by CHD (81.58%). The other diseases were osteoarthritis (51.32%), diabetes (34.21%). Assessing daily activities by ADL and IADL scales, our group was well-organized and fit in daily living (median ADL 6.0 [IQR, 6.0–6.0]; median IADL 25.0 [IQR, 22.0–26.0]). The characteristic of the group is shown in Table 1 and 2.

Table 1. Characteristics of the study group in relation to nutritional status and physical performance.

Variable	Mean (SD) or Median [IQR] or Percentage
BMI (kg/m^2)	27.88 (4.58)
MNA score (0–30)	25.5 [23.5–27.0]
MNA <24 points (n = 22)	25%
6MWT (m)	359.5 [305.0–412.5]
TUG (s)	10.0 [9.0–12.0]
GS (m/s)	0.80 [0.67–1.0]
Albumin (g/L)	44.03 (2.87)

Abbreviations: BMI — Body Mass Index, MNA — Mini Nutritional Assessment, 6MWT — Six Minute Walk Test, TUG — Timed Up & Go Test, GS — gait speed.

Table 2. Characteristics of the study group according to the body composition parameters.

Body composition	Median [IQR]
LBM (kg)	47.47 [40.41–53.96]
ALM (kg)	20.55 [16.33–22.79]
Upper extremity fat (%)	29.7 [23.9–41.3]
Upper extremity fat (g)	2471.00 [1853.0–3298.0]
Lower extremity fat (%)	31.45 [25.65–40.15]
Lower extremity fat (g)	6679.0 [5250.5–9445.5]
Trunk fat (%)	41.5 [32.9–45.45]
Trunk fat (g)	15769.00 [12453.0–19462.0]
Total fat (%)	35.19 [29.60–41.00]
Total fat (g)	26161.00 [20802.0–33795.0]

Abbreviations: LBM — Lean Body Mass, ALM — Appendicular Lean Mass

Unadjusted Analyses

To assess the relationship between physical performance indicators, nutritional status and tissue distribution we performed correlation analysis. Table 3 summarized only statistically significant associations revealed due to analysis.

Gait speed correlated negatively with age, and faster gait was associated with greater muscle mass and higher MNA score.

Time for TUG correlated positively with age and the number of comorbidities and negatively with MNA score, albumin level and muscle mass.

Negative correlations between 6MWT and age, as well as percentage of lower extremity fat were found, while the distance covered positively correlated with MNA score, and muscle mass. The correlations were shown in the Table 3.

Table 3. Summary of the correlation analysis between physical performance indicators, nutritional status and body composition parameters.

Correlation		rho (correlation coefficient)	p-value *
Gait speed	Age (years)	–0.39	<0.0001
	MNA (score)	0.29	0.0024
	ALM (kg)	0.26	0.0269
	LBM (kg)	0.24	0.0365
TUG	Age (years)	0.45	<0.0001
	MNA (score)	–0.39	<0.0001
	ALM (kg)	–0.30	0.0077
	LBM (kg)	–0.23	0.0412
	Albumin (g/L)	–0.23	0.0182
	No. of comorbidities	0.31	0.0009
6MWT	Age (years)	–0.40	<0.0001
	MNA (score)	0.24	0.0124
	ALM (kg)	0.4	0.0004
	LBM (kg)	0.31	0.0057
	Lower extremity fat (%)	–0.27	0.0155

Abbreviations: MNA — Mini Nutritional Assessment, ALM — Appendicular Lean Mass, LBM — Lean Body Mass, 6MWT — Six Minute Walk Test

* P-value was assessed by means of Spearman correlation analysis

Multiple Regression Analyses

In order to find out whether the parameters of nutritional status and body composition independently affect physical performance (GS, 6MWT, TUG), stepwise regression models were built.

The set of the independent variables were identified based on the results of correlation analyses. It included following variables: age, sex, MNA score, muscle mass (ALM or LBM), fat mass (percent of upper extremity fat/percent of lower extremity fat/percent of trunk fat/trunk fat in grams), the number of comorbidities and an albumin level.

We decided to include multimorbidity (expressed as the number of comorbidities) into the model because these variables were significant in the comparative analysis (data not shown). The summary of stepwise regression results is presented in Table 4.

Table 4. Summary of stepwise regression models.

Independent variables (at final step of stepwise regression)	Physical performance parameters (dependent variables)		
	GS (m/s)	TUG (after log-transformation)	6MWT (m)
	β (SE)	β (SE)	β (SE)
Age	-0.017 (0.004)$^{\#\#}$	0.01(0.003)**	-3.805 (1.131)**
Sex (male)	—	-0.119 (0.068)	—
MNA	0.038 (0.013)**	-0.031 (0.011)**	—
ALM	-0.02 (0.011)	—	—
Percent of lower extremity fat	-0.009 (0.004)*	—	-2.474 (1.026)*
No. of comorbidities	—	0.034 (0.013)*	—
Adjusted R2 for model	0.333	0.353	0.240

$p < 0.05$ *; $p < 0.01$**; $p < 0.001$#; $p \leq 0.0001$##
β — regression coefficient
SE — standard error

A stepwise regression analysis with GS as dependent variable and with age, sex, MNA, ALM/LBM, albumin level, percent of lower extremity fat and the number of comorbidities as independent variables revealed that GS is independently positively influenced by good nutritional status measured by MNA and negatively by older age and percent of lower extremity fat, but not by muscle mass.

In another model of stepwise regression, TUG was used as a dependent variable. Age, sex, MNA, ALM/LBM, albumin level, percent of lower extremity fat/percent of trunk fat/trunk fat in grams and the number of comorbidities were identified as independent variables. This model showed that people with older age, poorer nutritional status and a higher number of comorbidities needed longer time to perform TUG.

In the last model of stepwise analysis, among the identified independent variables (age, sex, percent of lower extremity fat, ALM/LBM, the number of comorbidities), age and percent of lower extremity fat negatively influenced 6MWT.

Discussion

In this study, we evaluated the relationship between body composition, nutritional status and physical performance in the Polish outpatient geriatric population. We found that the physical performance is influenced by age, multimorbidity, nutritional status, and parameters of body composition: fat mass.

Gait speed

A stepwise regression model revealed that GS was independently negatively influenced by older age and higher percentage of lower extremity fat while it was positively associated with better nutritional status measured by MNA. We did not find an independent relationship between GS and ALM.

Partly in line with our studies, Nasimi *et al.* in their study indicated that old age, high body fat mass, and low BMI were the risk factors of low GS [16]. Authors suggested that older age, male sex, low BMI, decreased MNA score, low serum albumin level, and high body fat were associated with a higher risk of sarcopenia [16]. A negative correlation between walking speed and percent of body fat was also demonstrated by Chao *et al.* [13] and Waters *et al.* [9], in the latter study this relationship was shown in women but not in men. The difference with our study is that we found a relationship between slow walking and the percentage of lower extremity fat.

In addition, Ramsey *et al.* revealed that malnutrition was most strongly associated with gait speed and chair stand test [1].

Better nutritional status and lower risk of malnutrition assessed with the MNA may indirectly indicate a lower risk of sarcopenia, which is also associated with the ability to walk faster.

Unlike in our study, some authors have found a relationship between slow gait and low lean mass [11] although in one study only in men [9]. Similar to our results, a lack of such a relationship was described by Woods *et al.* [12], Zeng *et al.*[15], and Chao *et al.* [13].

Timed Up & Go Test

Our analysis showed that people with older age, poorer nutritional status, and a higher number of comorbidities needed longer time to perform TUG.

Current academic consensus confirms a relationship between TUG time and age [12, 22–24]. Although TUG performance is partly related to the walking speed and to the ability to rise from the chair, we did not find a relationship between log_TUG and muscle mass. Similarly, no such relationship was found by Woods *et al.*, although in their study TUG was related to hip abductor strength [12]. Contrary to these results, Takenaka *et al.* demonstrated influence of appendicular muscle mass index on TUG performance [22].

Additionally, in concordance with our studies, Ramsey *et al.* stated that there is a significant relationship between malnutrition and TUG [1].

Apart from this, according to the survey by Rijssen *et al.* being malnourished by ESPEN definition was significantly associated with higher TUG time [25].

Notably, in our study TUG time was influenced by multiple morbidities. TUG is a measure of overall functional mobility, assessing the ability to transfer, walk, and change direction. Performing these complex activities depends on mobility, balance, coordination, and muscle strength which may be worsened by chronic diseases.

Six Minute Walk Test

In the last model of stepwise analysis, age and percent of lower extremity fat negatively influenced 6MWT.

Partly in line with our study, Vilaça *et al.* showed that body fat negatively influences functional performance, even among active elderly women. The group that walked the shortest distance in 6MWT had a higher BMI, greater amount of fat mass, lower handgrip strength, lower knee extension strength, lower arm muscle quality and lower leg muscle quality. There was no significant difference between muscle mass ($p = 0.25$) and lean mass ($p = 0.26$) [26].

In our study we did not confirm the relationship between muscle mass and 6MWT, but we stated that percent of lower extremity fat negatively influenced 6MWT. At variance, Pelegrino *et al.* revealed in their study that the distance covered on 6MWT was similar in COPD patients with and without LBM depletion (470.3 +/– 68.5 m vs 448.2 +/– 89.2 m) and no significant association was found between the indicators of body composition and 6MWT [14].

Obviously, there are other surveys regarding the relationship between body composition, nutrition and physical ability. Some of them show that a high percentage of fat and low muscle mass are associated with functional decline [4, 27–29] and, to be more detailed, higher tFMI (trunk fat mass index) using DXA was correlated with low physical performance and balance [30, 31] but, on the other hand, a positive correlation was found between physical activity and lean mass [31–32].

Regardless of the differences found in the results of the aforementioned studies, fat and muscle mass of body composition turned out to be important for physical fitness. Physical activity was identified as the most important factor in building muscle mass and contributing to the reduction of adipose tissue.

Of note, our survey was conducted within a specific group — geriatric patients with many concomitant diseases. In contrary to our study group, in the literature there are different studies connected with this topic but many of them were implemented on Asian populations. Many studies also refer to postmenopausal women, whereas others do not highlight the impact of concomitant disorders.

Conclusion

Age and nutritional status remain a strong determinant of physical fitness deterioration. Different measures of physical performance are influenced by different elements of body composition — no single element of body composition was found determining the deterioration of all assessed parameters of physical fitness.

Overall, it can be concluded that, our findings will bring about further novel clinical research on cause and effect of relationships between body composition, malnutrition and physical performance.

This study will shed light with regards to the Polish outpatient geriatric population's perspective.

Limitations

We are aware of some limitations of this study. Firstly, the cross-sectional nature of the study does not allow assessment of the causative relationship between body composition, malnutrition and physical performance — this warrants further investigation. Secondly, the number of patients included in this analysis is quite small and that limits the statistical power, limiting the study of how confounders might have an impact on study outcomes. The small number of participants also does not allow for the separate assessment of women and men, but both sexes were included. In addition to this, the group is heterogeneous and, as previously written, relatively small, so that might influence study outcomes. The result of this study could not apply to the general geriatric population due to the high prevalence of CHF and CHD. However, participants were typical of the Polish geriatric outpatients.

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Conflict of interest

None declared.

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