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Original Article

Correlation between Body Composition and Physical Performance in Aged People

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SUMMARY

Background: With age, body composition often changes with functional limitations in elderly adults. What kind of body composition evaluation method had better correlation with physical capacity is unclear. The aim of this study was to investigate the correlation between body composition and physical capacity aged people.
Methods: 56 males (mean age, 63.60 ± 7.24 years) and 64 females (mean age, 63.27 ± 7.23 years) were enrolled in this cross-sectional study during January and December 2016. Body composition was measured by dual-energy X-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA). Physical performance was evaluated using the timed up-and-go, open eye single-leg stance, timed chair-rise, and 10-m walk speed tests. The association was analysed by Pearson test.
Results: In elderly female participants, the fat percentage obtained using DXA was found to be associated with the single-leg stance ($r = -0.306$, $p < 0.05$), timed chair-rise ($r = -0.318$, $p < 0.05$), and timed up-and-go ($r = 0.252$, $p < 0.05$) test results. Moreover, lean mass percentage obtained using DXA was associated with the single-leg stance ($r = 0.312$, $p < 0.05$) and timed chair-rise ($r = 0.294$, $p < 0.05$) tests. But no association was found between BIA body composition and physical performance. The body composition by BIA and DXA were unassociated with physical performance in male and total participants.
Conclusions: DXA analysis for body fat percentage is negatively associated and muscle mass percentage is positively associated with physical capacity in women older than 50 years, but not in their male counterparts.

1. Introduction

Body composition often changes with age, and previous studies have indicated that despite no change in body weight and physical activity, increased fat and decreased lean mass can be observed.[1] These changes in body composition with age could lead to functional limitations in the elderly adults.[2] Moreover, they can restrict daily activity participation and the ability to perform self-care tasks, thus leading to dependence. Therefore, elucidating the correlation between body composition and physical capacity in elderly people is essential.

To accurately estimate the body composition, various methods, such as magnetic resonance imaging (MRI), computed tomography (CT), dual-energy X-ray absorptiometry (DXA), and bioelectrical impedance analysis (BIA), have used.[3] However, MRI and CT are expensive and time-consuming. In addition, DXA is considered a gold standard measurement tool for body composition, particularly for fat and lean mass evaluation. BIA is considered one of the most practical methods for estimating body composition in different groups because of its ready accessibility, low cost, quick assessment

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procedures, and high validity against DXA as the reference method.[4] Besides, a recent study applied a leg-to-leg bioelectrical impedance analyser to estimate with abdominal visceral fat of the elderly, and they found highly positive correlated to CT scanning in Chinese elderly individuals.[5] Based on above reason, we choose BIA and DEXA for evaluation of body composition in this study.

Which body composition parameter changes and its impact on the physical capacity of elderly people remains debatable. With population ageing and the associated functional impairments and disability concerns, it is important to determine the influence of body composition changes and their correlations with physical function before frailty. As best of our knowledge, there was no relevant data of physical capacity and body composition among healthy elderly people in Taiwan. Based on above reason, we conducted a cross-sectional study to investigate the gender difference in the correlation between body composition and physical capacity in elderly people. Besides, which body composition evaluation is better associated with physical performance of elderly people is not well investigated. The secondary aim of our study was to analyse the association of physical capacity by BIA or DXA body composition assessment among different gender elderly people.

2. Methods

2.1. Participants and study design

The study participants were recruited from the local community around a university hospital in Taipei. The inclusion criteria were as follows: older than 50 years and younger than 80 years, living in community (not institutionalised), and independence in activities of daily living. The exclusion criteria were a history of severe musculoskeletal disorders or previous receipt of arthroplasty and artificial implants, which can influence the body composition due to muscle wasting; a history of endocrine disorders such as hypothyroidism and hyperthyroidism; current steroid use (in recent 6 months); a history of neurological injuries; and no tolerance for the physical capacity evaluation in this study. To account for the influence of sex and age on body composition in this cross-sectional study, we recruited 120 participants during January to December 2016. Body composition was measured through BIA and DXA. Physical capacity was evaluated using the single-leg stance test with or without the eyes closed, the number of sit-to-stand and stand-to-sit cycles in 30 s, timed-up-and-go test, and a 10-m walk test. This study was approved by the Institution Review Board of Taipei Medical University (IRB No. N201602035) and met the STROBE study guideline of cross-sectional studies. All the study procedures were explained to the participants before they signed an informed consent declaration.

2.2. Body composition evaluation

Initially, we measured the body composition of the participants with an eight-polar BIA device with a multifrequency current applied (Inbody™ 220, Biospace, Seoul, South Korea). The impedance was evaluated by applying two frequencies (20 and 100 kHz) to the four limbs and trunk. The examination process is detailed as follows: the participants stood upright with their bare feet placed on foot electrodes and their upper limbs abducted by gripping the hand electrode handles. Then, demographic data such as age, sex, and height were input into the machine. Data on the participants' body weight, body mass index, lean muscle mass, fat mass, and fat percentage are presented after the analysis results.

In addition to BIA, we adopted DXA for the body composition evaluation. Measurements in all the participants were performed through DXA by conducting whole-body scans using a Hologic Delphi densitometer (Hologic, Waltham, MA, USA). Data on the total lean muscle mass, lean muscle percentage, fat mass, fat percentage, T-score, Z-score, and bone mineral density (BMD) were analysed.

2.3. Physical capacity evaluation

We used the single-leg stance test to assess the balance ability of the participants. The participants were asked to stand on one leg without shoes with both hands on the hip and the heel of the other leg elevated to the calf height of the leg on which they were standing.[6] The test was performed two times with both legs with or without closed eyes, and the most efficient performance data were recorded. The timed chair-rise test was chosen to evaluate lower-extremity muscle strength. The participants were asked to sit with their arms folded on their chest in a straight-back chair with the back of the chair against a wall.[7] Subsequently, they were asked to stand upright from the seated position in a chair and then return to the seated position as many times as possible within 30 s. For the timed-up-and-go test, a line was drawn on the floor 3 m from a chair, and the height of the chair was between 40 and 45 cm above floor level. Participants were asked to rise from the chair with their hands on the armrest, walk at a self-determined and safe speed toward the line, and return to the previous seated position.[8] The time taken to perform the task was measured. Walking speed was evaluated using the 10-m walk test. Participants walked at their preferred speeds, and the time taken to traverse 10 m was recorded.[9]

2.4. Statistical analyses

Descriptive analysis was performed for both the male and female groups, and the means and standard deviations are presented. Pearson's test was performed to determine the association between the body composition variables and physical capacity variables. We hypothesized that DXA body composition and had better association for age people. And more fat composition had less physical capacity. Whereas more lean muscle mass aged people had better physical capacity. All data analyses were performed using IBM SPSS 20.0, with $P < 0.05$ considered statistically significant.

3. Results

A total of 56 male (mean age, 63.60 ± 7.24 years) and 64 female (mean age, 63.27 ± 7.23 years) participants were recruited. The BIA of male participants found 18.41 ± 5.1 Kg of body fat (26.29 ± 5.16%) and the DXA data of them were 20.32 ± 4.28 Kg (29.41 ± 3.42%) of body fat and 45.84 ± 4.87 Kg (66.42 ± 3.19%) of lean mass. With regards to physical function, the left leg stance test was 22.43 ± 9.86 s; the right leg stance test was 22.43 ± 9.45 s; the 30 s of timed chair-rise test was 16.77 ± 5.69 times; the timed-up-and-go test was 6.82 ± 1.73 s, and gait speed was 1.39 ± 0.26 m per second. For female participants, the BIA data was 20.88 ± 6.62 Kg (35.46 ± 6.86%) of fat and the DXA data for lean mass was 32.73 ± 4.03 Kg (56.88 ± 3.92%) of lean mass and 22.96 ± 5.13 Kg (39.62 ± 4.25%) of fat. In the physical function aspect, the left leg stance test was 22.63 ± 9.32 s; the right leg stance test was 22.74 ± 9.42 s; the 30 s of timed chair-rise test was 16.23 ± 4.36 times; the timed-up-and-go test was 6.67 ± 1.05 s, and gait speed was 1.45 ± 0.45 m per second (Table 1). No association was found of body composition by BIA and DXA, and physical capacity parameters of total participants (Table 2). There was positive association of body weight and timed-up-and-go test ($r = 0.269$, $p < 0.05$) but no significant association was observed between the body composition by both BIA and DXA and physical capability tests of the elderly

Table 1
Anthropometric parameters, bone mineral density (BMD), body composition parameters, and physical capability tests of healthy elderly from the community.

Variables	Total (n = 120)		Male (n = 56)		Female (n = 64)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	63.43	7.20	63.61	7.24	63.27	7.23
Weight (kg)	62.64	10.08	68.57	8.45	57.46	8.43
Fat BIA (kg)	21.73	4.92	18.41	5.10	20.88	6.62
Fat BIA (%)	34.86	6.41	26.29	5.16	35.46	6.86
Fat DXA (kg)	38.85	7.92	20.32	4.28	22.96	5.13
Fat DXA (%)	61.33	5.98	29.41	3.42	39.62	4.25
Lean mass DXA (kg)	63.43	7.20	45.84	4.87	32.73	4.03
Lean mass DXA (%)	62.64	10.08	66.42	3.19	56.88	3.92
BMD	1.14	0.86	1.291	1.23	1.00	0.12
T score	−1.05	1.48	−0.77	1.25	−1.30	1.63
Z score	−0.40	1.12	−0.32	1.15	−0.46	1.10
LLS (s)	22.54	9.54	22.43	9.86	22.63	9.32
RLS (s)	22.59	9.40	22.43	9.45	22.74	9.42
TCR (times)	16.48	5.01	16.77	5.69	16.23	4.36
TUG (s)	6.74	1.41	6.82	1.73	6.67	1.05
Gait speed (m/s)	1.43	0.37	1.39	0.26	1.45	0.45

BIA: bioelectrical impedance analysis; DXA: dual-energy X-ray absorptiometry; BMD: bone marrow density; LLS: left leg stance; RLS: right leg stance; TCR: timed chair-rise; TUG: timed up-and-go.

male participants (Table 3). The DXA body fat percentage measurements correlated negatively with the single-leg stance test ($r = -0.306$, $p < 0.05$) and 30-s timed chair-rise test ($r = -0.318$, $p < 0.05$) and positively with the timed-up-and-go test ($r = 0.252$, $p < 0.05$) for the female participants. Additionally, the DXA lean muscle mass percentage measurements correlated positively with the single-leg stance test ($r = 0.312$, $p < 0.05$) and 30-s timed chair-rise test ($r = 0.294$, $p < 0.05$), but no association was found between BIA body composition and physical capacity among female participants (Table 4).

4. Discussion

Our study investigated the association between body composition and physical capacity in elderly people older than 50 years. We observed that body fat and lean mass percentage obtained through DXA were associated with physical capacity variables for the female participants. In elderly women, evidence has revealed that the initiation and progression of disability can be caused by changes in body composition.[10] In addition, that study found that a decrease in the cross-sectional area of the lower limb muscles was associated with mobility limitation, impaired balance, and increased risk of fall. Reid et al. also found that lean muscle mass was associated with muscle strength and that decreased muscle mass led to decreased mobility in elderly people.[11] This finding implies that lower fat mass and higher muscle mass in elderly women could indicate higher physical capacity.

In this study, an association was found between body composition and physical capacity among the female participants but not their male counterparts. This finding could be attributed to the higher functional limitations in women than in men during the ageing process. In elderly women, menopause is accompanied by changes in body composition, which are characterised by an increase in body fat and a progressive decrease in muscle mass and strength. Based on the characteristics of body composition changes after menopause in elderly women, the body composition of muscle and fat percentage could be associated with physical capacity. Although there were researches about the muscle quality can be contributor to physical capacity of aged adults, the association impact by difference sex was not investigated thoroughly. Our

Table 2
Pearson association analysis between variables among aged total participants.

	Age (years)	Weight (kg)	Fat BIA (kg)	Fat BIA (%)	Fat DXA (kg)	Fat DXA (%)	Lean DXA (kg)	Lean DXA (%)	BMD	T_score	Z_score	LLS (s)	RLS (s)	TCR (times)	TUG (s)	Gait speed (m/s)
Age (years)	1.000															
Weight (kg)	−0.061	1.000														
Fat BIA (kg)	0.073	0.574**	1.000													
Fat BIA (%)	0.126	0.054	0.838**	1.000												
Fat DXA (kg)	0.048	0.578**	0.926**	0.755**	1.000											
Fat DXA (%)	0.104	−0.168	0.605**	0.866**	0.699**	1.000										
Lean DXA (kg)	−0.101	0.877**	0.156	−0.377**	0.116	−0.615**	1.000									
Lean DXA (%)	−0.114	0.183*	−0.59**	−0.855**	−0.686**	−0.996**	0.627**	1.000								
BMD	−0.108	0.218*	0.074	−0.047	0.030	−0.137	0.248*	0.140	1.000							
T_score	−0.058	0.217*	0.008	−0.135	−0.042	−0.253*	0.265**	0.202*	0.091	1.000						
Z_score	0.132	0.140	0.057	−0.019	0.024	−0.100	0.129	0.041	0.049	0.878**	1.000					
LLS (s)	−0.121	0.012	−0.053	−0.069	−0.025	−0.041	0.029	0.048	0.070	0.035	−0.028	1.000				
RLS (s)	−0.079	0.062	−0.035	−0.103	−0.021	−0.089	0.084	0.088	0.091	0.186*	0.142	0.672**	1.000			
TCR (times)	−0.102	0.040	−0.052	−0.113	−0.068	−0.15	0.093	0.160	0.058	0.074	0.052	0.116	0.056	1.000		
TUG (s)	0.061	0.061	0.065	0.043	0.055	0.022	0.039	−0.036	−0.013	0.004	0.023	−0.391**	−0.243*	−0.549**	1.000	
Gait speed(m/s)	−0.028	0.068	0.116	0.115	0.141	0.118	0.005	−0.106	0.000	−0.075	−0.085	0.174	0.111	0.223*	−0.367	1.000

*$P < 0.05$, **$P < 0.005$, BIA: bioelectrical impedance analysis; DXA: dual-energy X-ray absorptiometry; BMD: bone marrow density; LLS: left leg stance; RLS: right leg stance; TCR: timed chair-rise; TUG: timed up-and-go.

Table 3
Pearson association analysis between variables among aged male participants.

	Age (years)	Weight (kg)	Fat BIA (kg)	Fat BIA%	Fat DXA (kg)	Fat DXA (%)	Lean DXA (kg)	Lean DXA (%)	BMD	T_score	Z_score	LLS (s)	RLS (s)	TCR (times)	TUG (s)	Gait speed (m/s)
Age (years)	1.000															
Weight (kg)	−0.137	1.000														
Fat BIA(kg)	0.116	0.795**	1.000													
Fat BIA (%)	0.238	0.502**	0.919**	1.000												
Fat DXA (kg)	0.002	0.892**	0.927**	0.756**	1.000											
Fat DXA (%)	0.136	0.553**	0.835**	0.852**	0.865**	1.000										
Lean DXA (kg)	−0.239	0.924**	0.553**	0.204	0.653**	0.199	1.000									
Lean DXA (%)	−0.187	−0.497**	−0.786**	−0.817	−0.818**	−0.979**	−0.137	1.000								
BMD	−0.136	0.198	0.178	0.123	0.120	0.015	0.235	0.006	1.000							
T_score	0.109	0.074	0.002	−0.008	−0.007	−0.073	0.079	−0.038	−0.010	1.000						
Z_score	0.250	0.042	0.012	0.023	−0.013	−0.055	0.033	−0.062	−0.039	0.988**	1.000					
LLS (s)	−0.159	0.167	0.177	0.152	0.213	0.217	0.103	−0.194	0.099	−0.055	−0.072	1.000				
RLS (s)	−0.108	0.147	0.016	−0.055	0.058	−0.034	0.194	0.041	0.119	0.124	0.102	0.643**	1.000			
Updown 30 s (times)	−0.152	0.105	0.045	−0.018	0.057	−0.037	0.143	0.101	0.046	−0.083	−0.113	0.120	0.086	1.000		
TUG (s)	0.113	−0.053	−0.011	0.025	−0.049	−0.008	−0.060	−0.054	−0.021	0.090	0.107	−0.409*	−0.230	−0.672**	1.000	
Gait speed(m/s)	−0.104	0.269*	0.167	0.068	0.249	0.158	0.254	−0.107	0.037	−0.187	−0.204	0.472*	0.280*	0.587**	−0.724**	1.000

*$P < 0.05$, **$P < 0.005$, BIA: bioelectrical impedance analysis; DXA: dual-energy X-ray absorptiometry; BMD: bone marrow density; LLS: left leg stance; RLS: right leg stance; TCR: timed chair-rise; TUG: timed up-and-go.

Table 4
Pearson association analysis between variables among aged female participants.

	Age (years)	Weight (kg)	Fat BIA (kg)	Fat BIA%	Fat DXA (kg)	Fat DXA (%)	Lean DXA (kg)	Lean DXA (%)	BMD	T_score	Z_score	LLS (s)	RLS (s)	TCR (times)	TUG (s)	Gait speed (m/s)
Age (years)	1.000															
Weight (kg)	−0.046	1.000														
Fat BIA (kg)	0.055	0.884**	1.000													
Fat BIA (%)	0.137	0.639**	0.912**	1.000												
Fat DXA (kg)	0.096	0.920**	0.922**	0.781**	1.000											
Fat DXA (%)	0.254*	0.537**	0.703**	0.775**	0.816**	1.000										
Lean DXA (kg)	−0.192	0.883**	0.656**	0.339*	0.631**	0.091	1.000									
Lean DXA (%)	−0.248*	−0.533**	−0.695**	−0.762**	−0.811**	−0.993**	−0.084	1.000								
BMD	−0.296*	0.228	0.113	−0.001	0.085	−0.137	0.301*	0.052	1.000							
T_score	−0.180	0.197	0.068	−0.052	0.012	−0.251*	0.337*	0.181	0.845**	1.000						
Z_score	0.022	0.206	0.114	0.022	0.085	−0.110	0.262*	0.024	0.931**	0.826**	1.000					
LLS (s)	−0.086	−0.114	−0.224	−0.269*	−0.216	−0.306*	0.029	0.312*	0.045	0.104	0.015	1.000				
RLS (s)	−0.053	0.030	−0.077	−0.2	−0.089	−0.266*	0.156	0.260*	0.187	0.241	0.180	0.700**	1.000			
Updown 30 s (times)	−0.050	−0.092	−0.121	−0.18	−0.167	−0.318*	0.010	0.294*	0.220	0.201	0.241	0.114	0.024	1.000		
TUG (s)	−0.012	0.173	0.186	0.183	0.226	0.252*	0.083	−0.236	−0.089	−0.111	−0.110	−0.386*	−0.276*	−0.343*	1.000	
Gait speed(m/s)	0.011	0.078	0.078	0.088	0.073	0.061	0.071	−0.053	−0.039	−0.014	−0.021	0.026	0.030	0.024	−0.159	1.000

*$P < 0.05$, **$P < 0.005$, BIA: bioelectrical impedance analysis; DXA: dual-energy X-ray absorptiometry; BMD: bone marrow density; LLS: left leg stance; RLS: right leg stance; TCR: timed chair-rise; TUG: timed up-and-go.

study results are in consistent with the findings of previous studies, which body composition of fat had physical function impacts more strongly in aged women than in men.[12,13] Besides, another study by Visser et al. mentioned that total body fat had the greatest independent association with lower limb physical performance in older women.[14] With concerning the muscle mass aspect, our study finding is inconsistent to a previous study, which revealed muscle quality is independently predicted physical function in older men, but not in women.[13] Different to our study, they didn't perform the analysis of physical capacity and body fat percentage. The mechanism for these findings of aged people is still under comprehensively investigated and elucidative.

Many methods have been applied to assess body composition. Previously, skinfold measurements were relatively easy; however, this method cannot accurately measure changes in fat free mass and could underestimate loss of fat free mass due to weight loss.[15] The BIA method has been proven to be one of the most practical methods for assessing body composition among different groups because it is readily accessible, takes little time to conduct, is low cost, and has high validity against DXA as the reference method[4] However, our study revealed no association between body fat percentage and physical capacity parameters by using by BIA in both the male and female participants. DXA has been considered as the gold standard for body composition analysis, and our study demonstrated an association between fat or lean muscle percentage and physical capability in elderly women. Therefore, we consider DXA to be more appropriate than BIA for evaluating the physical capability and changes in body composition among elderly women.

This study revealed that fat percentage and lean mass percentage obtained using DXA are more associated with the physical capacity of elderly women than men. Nevertheless, some study limitations should be addressed. First, this study adopted a cross-sectional design, and we enrolled only healthy elderly women and men in the community. Although we attempted to exclude comorbidities that could influence body composition and physical function, potential selection bias may have occurred because the participants were enrolled from the community near only one hospital. Second, information on nutritional status, smoking, alcohol consumption, and exercise habits were not obtained. We recommend that these variables be considered in future investigations. Finally, despite the excellent reliability, the strength and physical capacity of the participants were assessed through physical testing. Objective assessment equipment, such as an isokinetic dynamometer, can be used to assess the strength of limbs and further analyse the correlation between different body composition parameters.

5. Conclusion

This cross-sectional study demonstrated that body fat percentage and muscle mass percentage obtained through DXA are associated with physical capacity in women older than 50 years, but not in their male counterparts. Additional studies on interventions for comorbidity and impaired physical function are recommended in the future.

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Appendix A. Supplementary data

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