

Trunk fat mass correlates with balance and physical performance in a community-dwelling elderly population

Results from the Korean Frailty and aging cohort study

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Abstract

This study aimed to investigate whether trunk fat mass measured using dual-energy X-ray absorptiometry (DEXA) correlates with balance and physical performance.

This study utilized 2-year baseline data pertaining to 3014 participants from the database of the Korean frailty and aging cohort study. The trunk lean mass and fat mass were measured by DEXA. Trunk fat mass index (tFMI) was established using the following standard equation: Trunk fat mass (Kg)/height² (m²). The clinical balance tests were performed using the timed up and go test (TUG), total balance score in short physical performance battery (SPPB). We performed SPPB and evaluated independence of daily living using activities of daily living, instrumental activities of daily living (IADL), sarcopenia screening tool (SARC-F) and both hand grip power. In our study, we tried to check the correlation of tFMI with balance and physical performance and to determine the factors associated with tFMI.

The tFMI was positively correlated with mean values of 4 m gait speed, repeat chair stand time in SPPB, TUG, and SARC-F and negatively correlated with hand grip, IADL, total balance test score in SPPB, total SPPB score, and age. The results of the multiple generalized linear model analysis that assessed the factors associated with balance and physical performance indicated that tFMI had a significant correlation with repeat chair stand time in SPPB (seconds) (Beta estimate [B]: 0.252), TUG (seconds) (B: 0.25), 4 m gait speed (seconds) (B: 0.055), and total balance score in SPPB (B: -0.035).

Higher tFMI using DEXA was correlated with low physical performance and balance, indicating that trunk fat mass was associated with balance and physical performance in community-dwelling older people.

Abbreviations: ASMI = appendicular skeletal muscle index, B = beta estimate, BIA = bioelectrical impedance analyzer, BMI = body mass index, CI = confidence interval, CS-PFP = continuous-scale physical-functional-performance test, CT = computer tomography, DEXA = dual-energy X-ray absorptiometry, GLM = generalized linear model, K-ADL = Korean version of activities of daily living, KFACS = Korean Frailty and aging cohort study, K-IADL = Korean version of instrumental activities of daily living, MMSE-K = Korean version of mini mental state examination, MRI = magnetic resonance imaging, SARC-F = sarcopenia screening tool, SPPB = short physical performance battery, tFMI = trunk fat mass index, TUG = timed up and go, WC = waist circumference, WHR = waist-height ratio, WHO = World Health Organization.

Keywords: balance, physical performance, trunk fat mass

1. Introduction

About 30% to 40% of the elderly fall every year, and falls are a common cause of injuries and deaths among older people.^[1-3]

Balance-related issues are related to the risk of falls and falls-related injuries in older people.^[4-6] Also, impaired balance and muscle function are the most important risk factors for falls.^[1,3] Identification of physical performance and balance that is related

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to deterioration and remediable through rehabilitation treatment is an important goal of disability and fall studies.

Some studies suggested a unique link between the composition of trunk muscle and both balance and mobility.^[7,8] Among the elderly, poor trunk muscle composition, manifested by a high degree of fat infiltration, is related to a decrease in both balance and mobility even after controlling defects in leg muscle composition.^[7,8] Moreover, results from previous studies indicate a negative relationship between fat mass and physical performance in older adults.^[9–14] With regard to the relationship between adiposity and physical performance in elderly women, physical performance had a significant negative association with anthropometrics, showing that physical performance decreased as the adiposity measured by waist circumference (WC), waist-height ratio, and body mass index (BMI) increased.^[15]

Studies that used quantitative data on physical performance or balance to identify associations with fat masses are limited. Therefore, we aimed to identify the association between trunk fat mass which was measured by dual-energy X-ray absorptiometry (DEXA) and physical performance or balance by performing a cross-sectional analysis of a cohort of community-dwelling older adults. We hypothesized that a higher degree of fat infiltration to trunk fat mass attributes would be linked to both poor mobility and balance among older adults.

2. Method

2.1. Participants

The subjects of the study were aged 70 to 84 years who participated in the Korean Frailty and Aging Cohort Study (KFACS); this cohort study was launched in 2016 to identify and prevent risk factors for frailty among community-dwelling elders. In a multi-center longitudinal study, the KFACS recruited 3000 participants from 10 participating centers across Korean urban, agricultural, and urban rural areas between 2016 and 2017, who did not plan to move outside their current community within the next 2 years. Among them, community-dwelling elder people between the ages of 70 and 84 years who are stratified by age and gender were included in the study. A total of 3014 subject's participants (1432 men and 1582 women) were recruited in this survey. Personal interviews covering the state of health, education, social economic state included in the study were extracted and data pertaining to cognitive function (using the Korean version of mini-mental status examination [MMSE-K]), anthropometric measurements (height, body weight, BMI, lean mass by DEXA, etc), fall experience, questionnaires of “fall to worry,” and comorbidities were evaluated.

Among these participants, the author included male and female participants (aged 70–84) who performed DEXA, KFACS, physical performance tests (timed up and go test [TUG] and short physical performance battery [SPPB]), Korean version of activities of daily living (K-ADL), Korean version of instrumental activities of daily living (K-IADL) and sarcopenia screening tool (SARC-F) questionnaire. The followings were exclusion criteria.

- (1) Those who had a disease that could affect trunk muscle or trunk fat mass (eg, malignancy, cardiovascular diseases, pulmonary disease, endocrine system diseases such as diabetes mellitus, and thyroid diseases).
- (2) Those who had a disease that could affect balance (eg, osteoarthritis, rheumatoid arthritis, stroke, etc).

- (3) Those with a score of less than 23 in MMSE-K, in the questionnaire and corresponding test items.
- (4) Those whose test score data were not available.

This study was approved by the appropriate Institutional Review Board of Kyung Hee University Hospital (no. KHUHM-DIRB 2015-12-103).

2.2. Trunk fat mass index (tFMI)

Trunk fat mass was measured using DEXA. Previous studies^[9,11,12] used DEXA to quantify fat or muscle mass, or to develop indices such as calculated fat index (fat mass (kg)/height (m)²), additional appendicular skeletal muscle index (appendicular muscle mass (kg)/height (m)²) to investigate each body compartments. DEXA (GE Medical Systems Lunar, Madison, WI) was used to obtain the trunk fat mass which included those of the neck, chest, abdominal, and pelvic areas. We modified this equation, and tFMI was calculated as trunk fat mass divided by height squared (trunk fat mass (kg)/height (m)²).

2.3. Physical performance and balance measurement

Hand grip strength was measured using digital hand grip gauge (Takei TKK 5401, Takei Scientific Instruments, Tokyo, Japan). The grip strength of each hand was measured once. After a 3-minute wait, a second measurement performed same method. The highest measure of each hand was used in the analysis. Existing test guidelines for each test were followed to SPPB and TUG.^[16,17]

SPPB is a widely used tool to assess functional mobility. Each item of the balance at stand test that assesses whether an older individual can stand for >10 seconds in side-by-side posture, semi-tandem posture, and tandem posture. For gait speed assessment, the subject walked a total of 4 m at a usual pace, and the time taken to cover 4 m was measured. The test was repeated twice, and the mean of the 2 trials was used for analysis. For the repeat chair stand test, the subject was timed while performing 5 cycles of “stand up from and sit down on a chair” as quickly as possible. The score of respectively tests were scored based on a 5-point scale (0–4), with a total score ranging from 0 to 12 points.^[17] A higher score indicated better functional mobility.^[18,19] For the 3 m TUG test, the participant stands up from a chair without arm rests and walks 3 m at usual pace, turns at a marker, returns to the chair, and sits down. The TUG was defined as the time from the start to sit down.^[16] A lesser time taken to perform the test indicated better functional mobility.

2.4. The SARC-F screen for sarcopenia

SARC-F was used as a screening tool for diagnosing sarcopenia and the questionnaire consisted of the following 5 items: strength, assisted walking, rising from a chair, climbing stairs, and falls.^[20]

- (1) Strength: How difficult is it for you to lift up and carry an object weighing 4.5 kg?
- (2) Assisted walking: How difficult it is for you to walk from 1 corner of a room to another?
- (3) Rising from a chair: How difficult is it for you to get up from a chair (wheelchair) and get on the bed (floor mattress), or for you to get up from your bed (floor mattress) and sit on a chair (wheelchair)?

- (4) Climbing stairs: How difficult is it for you to climb a flight of 10 stairs without a break? Each item was scored as follows: 0 = no difficulty, 1 = slightly difficult, and 2 = very difficult or unable to do the tasks.
- (5) Falls: How many times did you fall in the last year? This question was answered as follows: 0 = no, 1 = 1–3 times, and 2 = 4 or more time. Each of 5 item scores were added to calculate the total score. A total score of >4 points was considered indicative of sarcopenia. The Korean version of SARC-F was validated.^[21] The SARC-F questionnaire was administered via a person to person interview.

2.5. ADL and IADL

ADL and IADL were used to evaluate the lifelong activities of the study subjects. The evaluation tools were newly developed to suit the Korean situation. K-ADL has 7 items: dressing, grooming, bathing, feeding, transferring, toileting, and controlling the bowels and bladder. Each item was rated 1 to 3 points, and higher scores were assessed as lower daily activities.^[22]

The K-IADL has 10 items: grooming, housekeeping, food preparation, laundry, move out to short distance without transportation, mode of transportation, shopping (goods), ability to handle finances, ability to use telephone, ability to handle medications. High scores in each item mean that independent life is difficult.^[22,23] K-ADL and K-IADL were validated in other trials.^[22–24]

2.6. MMSE-K

The MMSE is a simple tool used for assessing cognitive function.^[25,26] The MMSE-K is the Korean version of the MMSE. The MMSE-K includes the following items: orientation (10 points), verbal memory (6 points), concentration and calculation (5 points), language (3 points), praxis (3 points), judgment (2 points), and visuospatial construction (1 point).^[27] The MMSE-K was standardized and validated in Korean older adults.^[28,29] Scores range from 0 to 30 points, and higher scores indicate better cognitive function.

2.7. Statistical method

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20.0 for Windows (SPSS Inc., Chicago, IL), and statistical significance was determined at a *P* value of <.05. The Kolmogorov–Smirnov test was conducted to check the normal distribution of variables (age, IADL, ADL, SARC-F, MMSE-K, height, weight, trunk fat mass, and hand grip). The result found to a not normally distributed.

The study subjects' characteristics are presented as mean \pm standard deviation. Spearman analysis was performed to investigate the correlation between tFMI and each variable. Generalized linear model (GLM) analysis was performed to determine whether tFMI associated with balance and physical performance. Results with *P* values <.05 were considered statistically significant.

3. Results

3.1. General characteristics of the participants

Four hundred seventy-one participants were included in the present analysis (Fig. 1).

Data pertaining to general and anthropometric characteristics, physical performance and balance are presented in Table 1. This study included 471 people. Age (mean) was 75.14 ± 3.67 years, tFMI was 4.20 ± 1.47 (kg), and trunk fat mass was 10.54 ± 3.50 . We divided the contents of SPPB for evaluation.

3.2. Correlation between tFMI and each value

Table 2 showed correlation with each values. The tFMI was weakly positively correlated with mean 4-m gait speed (seconds) ($r = 0.18$, $P < .01$), repeat chair stand time (seconds) in SPPB ($r = 0.18$, $P < .01$), TUG (seconds) ($r = 0.17$, $P < .01$), SARC-F ($r = 0.17$, $P < .01$), weight ($r = 0.35$, $P < .01$), and BMI ($r = 0.79$, $P < .01$) and weakly negatively correlated with hand grip (Rt.: $r = -0.41$, $P < .01$, Lt.: $r = 0.41$, $P < .01$), IADL ($r = -0.17$, $P < .01$), total balance test score in SPPB ($r = -0.15$, $P < .01$), total SPPB score ($r = -0.15$, $P < .01$), age ($r = -0.12$, $P < .01$). Both dominant hand grip and nondominant hand grip power did not correlate with tFMI.

3.3. Balance test and physical performance associated with tFMI

Analysis of GLM with multi-variated analysis was performed to determine whether tFMI associated with balance and physical performance (Table 3). tFMI had a significant correlation with repeat chair stand time in SPPB (seconds) (Beta estimate [B]: 0.252), TUG (seconds) (B: 0.250), 4 m gait time (seconds) (B: 0.055), total balance score in SPPB (B: -0.035). The dependent variables were adjusted by age, sex, and MMSE-K, dominant hand grip power of participants.

4. Discussion

We found that tFMI is related to balance and physical performance. Other studies have reported that trunk muscle mass measured using computer tomography (CT) or magnetic resonance imaging (MRI) is associated with balance.^[30] In general, the fat increase is associated with functional disability and lower physical performance.^[31] Muscle weight and fat content are an important declining factor associated with age in physical performance.^[31] In other studies using DEXA, fat mass index divided by total fat mass, adiposity/obesity, is an important factor in the elderly affecting physical performance, rather than muscle mass itself. A previous study found that continuous-scale physical-functional-performance test (CS-PFP) and fat mass were negatively correlated with age, sex, and BMI in relation to CS-PFP.^[12] Also, the 1-leg standing time was short in higher total fat mass.^[11] Both studies^[11,12] showed that appendicular skeletal muscle index was not explained as a predictor for physical performance.

In addition, other studies have shown that BMI cannot be reflected in the body fat composition, so fat mass of each part is measured by bioelectrical impedance analyzer (BIA). In the case of intra-abdominal fat mass, there was a positive correlation with the abdominal circumference and trunk fat. A previous study showed that there is an association between body adiposity and postural balance in older women. A larger fat mass indicated poor balance control, which indicates that body adiposity level was related to postural control.^[32]

At present, the most accurate method of measuring skeletal muscle mass or fat mass was MRI or CT scan; however, due to

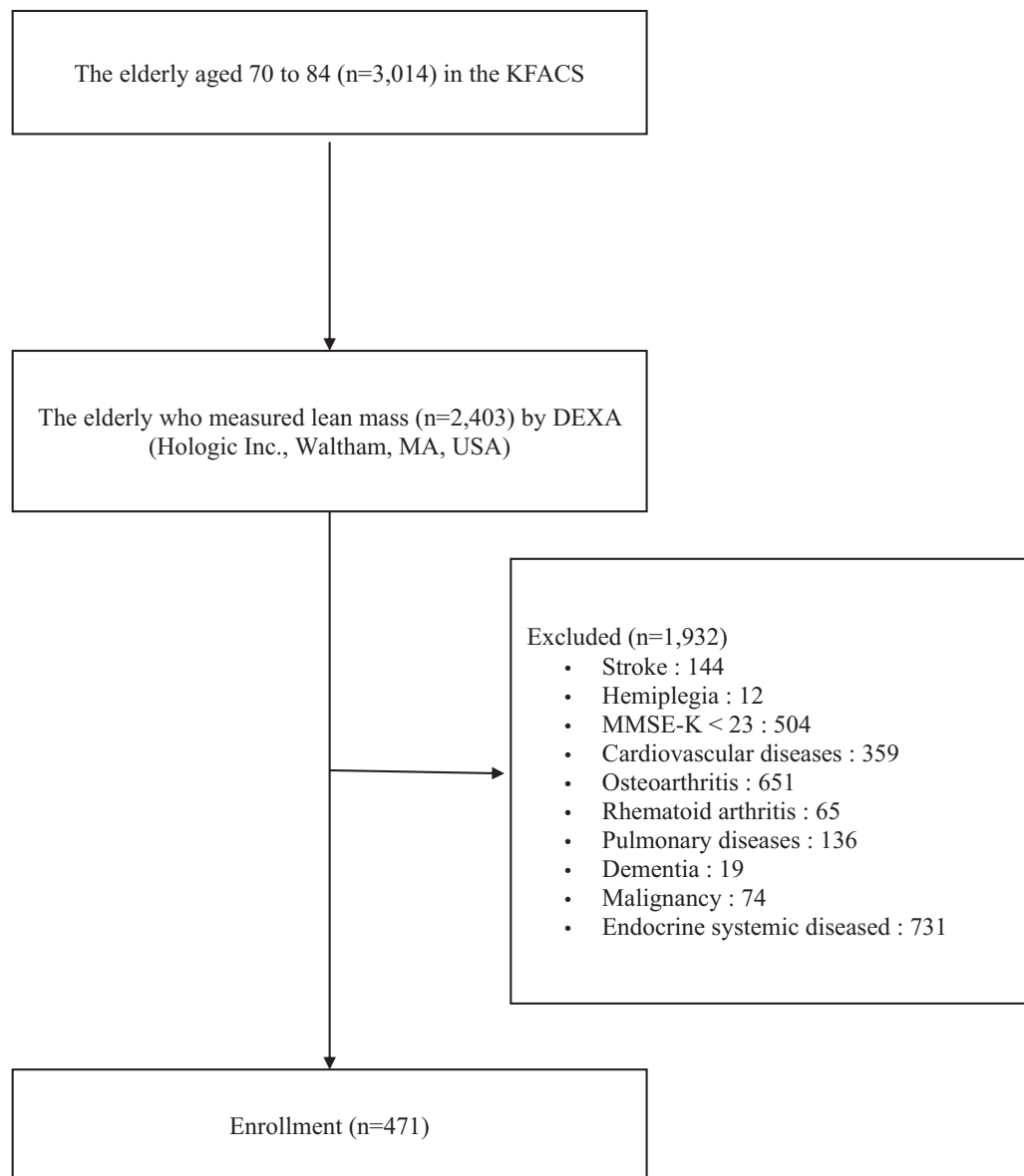


Figure 1. Flowchart of study selection and exclusion. DEXA = dual-energy X-ray absorptiometry, KFACS = Korean frailty and aging cohort study, MMSE-K = Korean version of mini mental state examination.

economic problems and inconvenience in use, there is a limit to using these modalities for screening. DEXA is a widely used method of conveniently measuring skeletal muscle mass and fat mass at a reasonable cost.^[33] In our study, we measured the muscle mass and fat mass with the advantage of DEXA and tried to investigate the relationship between trunk fat mass and balance or physical performance.

In 471 patients, the tFMI was positively correlated with 4 m gait time, repeat chair stand time, TUG, SARC-F, and WC. In addition, there was a negative correlation with both hand grip, IADL, total balance core, total SPPB score, and age. It was found that trunk fat mass correlated with balance and physical performance.

In the case of TUG that is associated with balance, total balance score of SPPB and 4 m gait time which is associated with physical performance correlated with tFMI in GLM analysis. It was found that trunk fat mass was associated with balance and

physical performance, and the relationship between age, sex, and tFMI was also confirmed. These results are similar to the results of the previous studies.^[9–14]

In addition, we found the association between tFMI and balance. tFMI showed a positive correlation with repeat chair stand time in SPPB, 4 m gait speed time and TUG time. The total balance score in SPPB was negatively correlated with tFMI. The result showed that when the tFMI was increased, the balance and physical performance were deteriorated, and tFMI associated with balance and physical performance. These results are similar to those of the previous studies.^[7,9–14]

In our study, higher trunk fat mass measured by DEXA was associated with lower balance ability and physical performance in the Korean elderly.

The limitations of this study are as follows. First, this study used data obtained from voluntary participants of the KFACS;

Table 1
Demographic characteristics of participants.

	246/225
Sex (male/female)	246/225
Age, yr	75.14 ± 3.67
Height, cm	159.17 ± 8.44
Weight, kg	61.06 ± 9.00
K-IADL (points)	10.79 ± 2.63
K-ADL (points)	7.06 ± 0.25
SARC-F (points)	0.48 ± 0.83
MMSE-K (points)	26.86 ± 1.90
Trunk lean muscle mass, kg	19.85 ± 3.42
Trunk fat mass, kg	10.54 ± 3.50
tFMI, kg/m ²	4.20 ± 1.47
Rt. hand grip, kg	26.51 ± 7.60
Lt. hand grip, kg	25.53 ± 7.58
Physical function	
Total balance score in SPPB (points)	3.79 ± 0.52
4 m gait time, s	3.33 ± 0.69
Repeated chair stand time, s	3.47 ± 0.80
Total SPPB score (points)	11.22 ± 1.06
TUG, s	9.56 ± 1.71

Values are presented as mean ± standard deviation.

K-ADL = Korean version of activities of daily living, K-IADL = Korean version of instrumental activities of daily living, MMSE-K = Korean version of mini-mental status examination, SPPB = short physical performance battery, SARC-F = sarcopenia screening tool, tFMI = trunk fat mass index (trunk fat mass (kg)/height (m)²), TUG = timed up and go test.

hence, there might be voluntary bias and recall bias in self-reporting questionnaires. Second, this is the first study reporting a correlation between trunk fat mass and balance and physical performance in Korea. But we excluded comorbidities that seemed to have an obvious effect, such as stroke, cancer, osteoarthritis, cardiovascular diseases, respiratory diseases, osteoarthritis. Although it is not representative of whole population group because community-dwelling older people might be healthier and more active.

In this study, high tFMI, measured using DXA, was positively correlated with repeated chair stand time, TUG and 4 m gait speed and negatively correlated with total balance score. High

Table 2
Spearman rho correlation of tFMI with balance and physical performance.

	r	P
Age	-0.121	<.05*
K-IADL	-0.165	<.001†
SARC-F	0.168	<.001†
Rt. hand grip	-0.409	<.001†
Lt. hand grip	-0.411	<.001†
Dominant hand grip	0.061	0.185
Non-dominant hand grip	0.073	0.114
Total balance score in SPPB	-0.148	<.05*
4 m Gait time	0.180	<.001†
Repeated chair stand time	0.177	<.05*
Total SPPB score	-0.148	<.05*
TUG	0.173	<.05*

BMI = body mass index, K-ADL = Korean version of activities of daily living, K-IADL = Korean version of instrumental activities of daily living, MMSE-K = Korean version of mini-mental status examination, SPPB = short physical performance battery, tFMI = trunk fat mass index (trunk fat mass (kg)/ height (m)²), TUG = timed up and go test.

* P < .05.

† P < .001.

Table 3
A multiple generalized linear model analysis the tFMI associated with balance and physical performance.

Dependent variables	Beta estimate (β)	Confidence interval (CI)	P
Total balance score in SPPB	-0.04	-0.07-0.00	<.05*
4 m gait speed time, s	0.06	0.00-0.10	<.05*
Repeat chair stand time, s	0.025	0.10-0.45	<.05*
Total SPPB score	-0.05	-0.12-0.02	.20
TUG, s	0.25	0.14-0.36	<.001†

All dependent variables (total balance score in SPPB, 4 m gait speed time, repeat chair stand time, repeat chair stand time, total SPPB score, TUG) were adjusted for age, sex, and MMSE-K, dominant hand grip power of participants.

MMSE-K = Korean version of mini mental state examination, SPPB = short physical performance battery, TUG = timed up and go test, tFMI = trunk fat mass index.

* P < .05.

† P < .001.

tFMI showed a significant relationship with balance and physical performance in community-dwelling older people in Korea.

Author contributions

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