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Original article

# Body composition analysis by bioelectrical impedance and its relationship with nutritional status in older adults: a cross-sectional descriptive study

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**Summary.** *Objective:* Measuring body composition gives an indication of the health status of older adults. To the best of our knowledge, there is no detailed investigation performed to assess body composition and its relationship with nutritional status in older adults, particularly in community-dwelling older adults. Thus, the aim of the study is to assess body composition and its relationship with nutritional status in older adults. *Methods:* A cross-sectional descriptive study with a multistage stratified sampling design was carried out in community-dwelling older adults in Riyadh city, the capital of the Kingdom of Saudi Arabia. Bioelectrical impedance analysis was used to analyze body composition. Furthermore, the association between body composition and nutrition status [assessed using the mini-nutritional assessment (MNA®) tool], was determined. *Results:* There were significant differences between older men and women with respect to body composition. Percentage body fat (PBF), fat mass, and fat mass index (FMI) were strongly positively correlated with body mass index (BMI). Those who were classified as malnourished had significantly lower BMI, PBF, fat mass, FMI, fat-free mass, and muscle mass compared to those classified as at risk of malnutrition or well-nourished. Multiple logistic regression highlighted the positive impact of various body composition measures on nutritional status. Calf circumference ≥31cm, significantly decreased the odds ratio (OR) of being malnourished (OR 0.055, C.I. 0.037-0.082). Conclusions: There are differences in body composition between older men and older women, and there is an association between body composition and nutritional status in older adults.

**Keywords:** Older adult; body composition; nutritional status; primary health care centers; Saudi Arabia.

## Introduction

Currently, in the Kingdom of Saudi Arabia (KSA), adults aged ≥ 60 years make up approximately 6% of the total population, and this is predicted to reach around 23% by the year 2050 (1). The expected changes in the age distribution of the population will increase the incidence and prevalence of many chronic diseases (2,3), which are known to occur more commonly in the Saudi older age group (4-6). A poor diet, in addition to sedentary lifestyle and genetics, plays a crucial role in the increased prevalence of many chronic diseases (7,8). For example, the prevalence of obesity, diabetes, dyslipidemia and hypertension in the KSA, which are known risk factors of cardiovascular disease, a major cause of death in the KSA, have reached 49.6%, 25.1%, 32.1% and 30.3%, respectively (9).

With ageing, there is a loss of lean body mass (mainly skeletal muscle), an increase in fat mass (10) and a decrease in resting energy expenditure (11). With the loss of muscle comes a loss of strength, and, consequently, older adults may become less active, which contributes to further loss of muscle. On the other hand, national surveys conducted in the KSA show that overweight and obesity have reached high rates in the adult population (12-14), which indicates that KSA is now facing a serious obesity-prevalence crisis. There has, however, been less focus on lean mass, and its functional significance, in the older Saudi population. Therefore, the current study aimed to assess body composition and the relationship between body composition and nutritional status in community dwelling older adults attending primary health care centers (PHCCs) in Riyadh city, KSA.

## Subjects and Methods

### *Study design*

The study was a cross-sectional descriptive study conducted in PHCCs in Riyadh city between January, 2015 and April, 2017, with a multistage stratified sampling strategy. A sample of 2,045 older adults (≥ 60 years of age) were enrolled in the study using sample size for proportion based on 2% degree of precision at 0.05 level of significance, and a design effect of 1.5 for cluster sampling. Fifteen PHCCs, identified according to geographical location (north, south, central, east, and west), were selected using the simple random sampling method, to represent the geographic sectors of Riyadh city. Sample size was selected proportionally to the population of each sector, stratified according to sex, and participants were selected consecutively.

Two trained physicians were selected from each PHCC to collect data (body composition and nutritional status) under regular supervision of the principle investigator. A signed consent form was obtained from each older adult before participating in the study.

### *Body composition*

The widest calf circumference (CC) was measured between the ankle and knee, without tightening, to the nearest 0.1 cm using a non-stretchable tape. Bioelectrical impedance analysis (BIA) was used to measure body composition. BIA is a safe, non-invasive method and is considered reliable for assessing body composition (15). A Tanita body composition analyzer (BC-418, Tanita Corporation, Japan) was used to conduct the analyses by direct segmental multi-frequency BIA (16,17) with eight polar electrodes applied to both feet and both hands. The device emits 50 and 500 kHz of electric current. It provides information about four body composition components, total body water (TBW), protein mass, mineral mass and fat mass; thus, body mass index (BMI), fat mass, % of body fat (PBF), fat-free mass (FFM), estimated muscle mass, TBW, and basal metabolic rate (BMR) were recorded by the device. Height was measured to the nearest 0.5 cm without shoes using a stadiometer, and then the subjects were requested to first wipe the soles of their feet and the palms of their hands with wet tissue, and then stand over the foot electrodes of the machine. Thereafter, subjects were asked to hold the hand electrodes, and to make sure that the hand electrodes were in contact with the five fingers. Fat mass index (FMI) was calculated by dividing the fat mass in kg, obtained from BIA, by height squared in meters (18). Muscle mass index (MMI) was calculated by dividing the muscle mass in kg, obtained from BIA, by height squared in meters. Individuals with dehydration, edema, metal implants, or having pacemakers, which are known to affect the flow of the electric current, were excluded.

### *Nutritional status*

Nutritional status was assessed by trained physicians (two for each PHCC) using the Arabic mini-nutritional assessment (MNA®-full form) tool (19). The MNA scale (0-30 points) consists of 18 point-weighted questions, which includes anthropometric measurements, global assessment, dietary questionnaires, and subjective assessment. Based on the MNA score, older adults were classified as malnourished (MN), score < 17 points; at risk of malnutrition (RM), score 17–23.5 points; or well-nourished (WN), score 24–30 points.

*Statistical analysis*

The Kolmogorov-Smirnov test was used to assess the normality of the data, and indicated that the data were not normally distributed. Therefore, data are presented as median and interquartile range. Mann-Whitney U test, Kruskal-Wallis test and Spearman correlation analysis were performed as appropriate. Statistical analyses were performed using Statistical Package for Social Science (SPSS) software, version 22 (IBM Company, USA). *P*-values < 0.05 were considered statistically significant. Furthermore, univariate and multivariate-binary logistic regression with "Enter method in SPSS" were performed to investigate, in depth, the association between anthropometric measurements as independent variables and nutritional status as a dependent variable (dichotomized as WN or RM and MN combined). The Hosmer-Lemeshow test was used to assess the goodness of fit ($P > 0.05$, in all models, indicating good fitting models). Odds-ratios with 95% confidence intervals (95% CI) were calculated.

## Results

The total number of older adults participating in the study was 2,045, of which 44.8% were women. The mean age was 66.2 years (67 ± 6.8 years for men and 65 ± 6.5 years for women), ranging from 60 to 98 years. The socio-demographic characteristics and the MNA classification of the older adults have been described elsewhere (20).

Table 1 shows that there were significant differences between men and women with respect to body

**Table 1.** Body composition indicators in male and female older subjects attending primary health care centers in Riyadh city

| Variables | Sex | Median | Interquartile range | Mean ± SD | P-value |
|---|---|---|---|---|---|
| BMI (kg/m2) | Male | 28.0 | 25.0-31.5 | 28.50 ± 5.31 | 0.001 |
| | Female | 30.5 | 27.0-34.0 | 30.92 ± 5.72 | |
| Body fat (%) | Male | 29.8 | 25.2-33.8 | 29.30 ± 6.85 | 0.001 |
| | Female | 40.4 | 36.2-44.3 | 39.75 ± 6.55 | |
| Fat mass (kg) | Male | 22.90 | 17.3-28.9 | 23.63 ± 9.28 | 0.001 |
| | Female | 29.15 | 23.6-36.3 | 30.31 ± 9.81 | |
| FMI (kg/m2) | Male | 8.37 | 6.3-10.6 | 8.66 ± 3.45 | 0.001 |
| | Female | 12.32 | 9.8-15.0 | 12.61 ± 4.10 | |
| Fat free mass (kg) | Male | 54.15 | 49.4-59.2 | 54.46 ± 7.73 | 0.001 |
| | Female | 43.65 | 40.3-47.3 | 44.22 ± 5.72 | |
| Muscle mass (kg) | Male | 51.70 | 47.3-56.6 | 52.06 ± 7.34 | 0.001 |
| | Female | 41.50 | 38.3-44.9 | 41.99 ± 5.41 | |
| Total body water (%) | Male | 51.4 | 48.4-54.7 | 51.74 ± 5.06 | 0.001 |
| | Female | 43.7 | 40.8-46.7 | 44.11 ± 4.80 | |
| Total body water (kg) | Male | 39.6 | 36.2-43.3 | 39.84 ± 5.65 | 0.001 |
| | Female | 31.9 | 29.5-34.6 | 32.37 ± 4.20 | |
| Basal metabolic rate (kcal) | Male | 1575 | 1441-1733 | 1596 ± 237 | 0.001 |
| | Female | 1323 | 1228-1451 | 1348 ± 175 | |

*Data were compared between males and females using the Mann Whitney test. $P < 0.05$ is considered statistically significant. SD: standard deviation; BMI: body mass index; FMI: fat mass index.*

composition measurements. Women had significantly higher BMI, PBF, fat mass, and FMI compared to men, while men had significantly higher FFM, muscle mass, %TBW, and TBW compared to women. BMR was higher in men compared to women.

Table 2 indicates that BMI, PBF, fat mass, FMI, and BMR were lower in the age category 70–79 years and ≥ 80 years compared to the age category 60–69 years. FFM, muscle mass, TBW, and BMR were significantly lower in the group aged ≥ 80 years old compared to the other age group categories.

Table 3 presents the results of Spearman correlation analysis among age, nutritional status (MNA score), and different anthropometric parameters. Age was inversely correlated with PBF, fat mass, FFM, FMI, muscle mass, BMI, BMR, and TBW, and positively correlated with %TBW, but these correlations were weak. PBF, fat mass and FMI were strongly

**Table 2.** Body composition indicators in older subjects attending primary health care centers in Riyadh city, according to age group

| Variable | Age range (y) | Median | Interquartile range | P-value |
|---|---|---|---|---|
| BMI (kg/m2) | 60 - 69 | 29.6a | 26.2-33.3 | |
| | 70 - 79 | 27.5b | 24.9-31.4 | 0.001 |
| | ≥ 80 | 26.7b | 23.7-30.4 | |
| Body fat (%) | 60 - 69 | 34.8a | 28.9-40.5 | |
| | 70 - 79 | 32.2b | 26.6-38.2 | 0.001 |
| | ≥ 80 | 32.3b | 26.5-38.3 | |
| Fat mass (kg) | 60 - 69 | 26.4a | 20.5-33.4 | |
| | 70 - 79 | 23.0b | 17.9-30.4 | 0.001 |
| | ≥ 80 | 22.3b | 16.1-29.5 | |
| FMI (kg/m2) | 60 - 69 | 10.3a | 7.8-13.2 | |
| | 70 - 79 | 8.8b | 6.7-11.9 | 0.001 |
| | ≥ 80 | 8.6b | 6.5-11.8 | |
| Fat free mass (kg) | 60 - 69 | 49.4a | 43.7-56.4 | |
| | 70 - 79 | 49.6a | 43.2-54.7 | 0.001 |
| | ≥ 80 | 46.7b | 40.6-51.7 | |
| Muscle mass (kg) | 60 - 69 | 47.0a | 41.6-53.7 | |
| | 70 - 79 | 47.1a | 41.2-52.2 | 0.001 |
| | ≥ 80 | 44.7b | 38.9-49.5 | |
| Total body water (%) | 60 - 69 | 47.8a | 43.6-52.1 | |
| | 70 - 79 | 49.7b | 45.3-53.8 | 0.001 |
| | ≥ 80 | 49.6b | 45.2-53.8 | |
| Total body water (kg) | 60 - 69 | 36.2a | 32.0-41.2 | |
| | 70 - 79 | 36.3a | 31.6-40.0 | 0.001 |
| | ≥ 80 | 34.2b | 29.7-37.8 | |
| Basal metabolic rate (kcal) | 60 - 69 | 1470a | 1317-1663 | |
| | 70 - 79 | 1452b | 1288-1608 | 0.001 |
| | ≥ 80 | 1384c | 1209-1521 | |

*Data were analyzed using Kruskal Wallis test followed by pairwise comparison using the Mann Whitney test. P < 0.05 is considered statistically significant. Significant differences between groups are marked with superscript letters on the median values. BMI: body mass index; FMI: fat mass index.*

**Table 3.** Spearman correlation coefficients for association between body composition measures, nutritional status (MNA), and age

| Measures | MNA | Age (y) | Body fat (%) | Fat mass (kg) | FFM (kg) | FMI (kg/m2) | Muscle mass (kg) | TBW (%) | BMI (kg/m2) | BMR (kcal) | TBW (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MNA | 1 | -0.242** | 0.108** | 0.233** | 0.282** | 0.188** | 0.279** | -0.110** | 0.278** | 0.308** | 0.278** |
| Age (y) | — | 1 | -1.43** | -0.153** | -0.034 | -0.162** | -0.029 | 0.142** | -0.171** | -0.070** | -0.033 |
| Body fat (%) | — | — | 1 | 0.880** | -0.257** | 0.950** | -0.270** | -0.998** | 0.749** | -0.108** | -0.257** |
| Fat mass (kg) | — | — | — | 1 | 0.196** | 0.961** | 0.183** | -0.882** | 0.919** | 0.341** | 0.194** |
| FFM (kg) | — | — | — | — | 1 | -0.014 | 1.000** | 0.255** | 0.315** | 0.986** | 0.998** |
| FMI (kg/m2) | — | — | — | — | — | 1 | -0.027 | -0.952** | 0.911** | 0.134** | -0.015 |
| Muscle mass (kg) | — | — | — | — | — | — | 1 | 0.268** | 0.304** | 0.983** | 0.997** |
| TBW (%) | — | — | — | — | — | — | — | 1 | -0.749** | 0.106** | 0.254** |
| BMI (kg/m2) | — | — | — | — | — | — | — | — | 1 | 0.445** | 0.313** |
| BMR (kcal) | — | — | — | — | — | — | —— | — | — | 1 | 0.984** |
| TBW (kg) | — | — | — | — | — | — | — | — | — | — | 1 |

*** $P < 0.01$. MNA: mini-nutritional assessment; FFM: fat free mass; FMI: fat mass index; TBW: total body water; BMI: body mass index; BMR: basal metabolic rate, TBW: total body water.*

positively correlated with BMI and strongly negatively correlated with %TBW. FFM was strongly positively correlated with muscle mass. Both FFM and muscle mass were strongly positively correlated with BMR and TBW. The MNA score was negatively associated with age and %TBW, and positively associated with other body composition parameters, but these correlations were weak.

When age and anthropometric measurements were classified according to nutritional status according to the MNA tool (Table 4), those who were classified as MN or RM were significantly older compared to those who were classified as WN. Those who were classified as MN had significantly lower BMI, PBF, fat mass, FMI, FFM, muscle mass, TBW, and BMR compared to those classified as RM or WN. These body composition measurements were also lower in those classified as RM group compared to the WN group.

Table 5 displays the results obtained from the multiple logistic regression between different body composition indices as independent variables and nutritional status (dependent variable). The results showed that for each unit increase in several independent variables (BMI, PBF, fat mass, FMI, muscle mass, the odds ratio [OR] of being classified as RM or MN decreased significantly ($P < 0.001$). In the adjusted model, the OR of the above measurements, ranged from 0.82 to 0.91 with the 95% CI range from 0.82–0.93. MMI significantly decreased the odds of being RM or MN to a greater extent (OR, 0.66; 95% CI, 0.61–0.71). With respect to the dichotomized CC, older adults with CC ≥ 31 cm, had significantly decreased the OR of being classified as MN or RM in the adjusted model, compared to those with CC < 31 cm (OR, 0.055; 95% CI, 037–0.082).

**Table 4.** Classification of age and anthropometric measurements of older subjects attending primary health care centers in Riyadh city according to nutritional status

| Variable | | Median | Interquartile range | P-value |
|---|---|---|---|---|
| Age (y) | Normal nutritional status | 62[a] | 60.0-68.0 | 0.001 |
| | At risk of malnutrition | 68[b] | 62.0-74.0 | |
| | Malnourished | 70[b] | 65.2-75.5 | |
| BMI (kg/m2) | Normal nutritional status | 29.8[a] | 26.6-33.3 | 0.001 |
| | At risk of malnutrition | 26.1[b] | 22.8-30.5 | |
| | Malnourished | 20.1[c] | 17.4-24.9 | |
| Body fat (%) | Normal nutritional status | 34.5[a] | 29.1-40.1 | 0.001 |
| | At risk of malnutrition | 32.1[b] | 25.0-39.2 | |
| | Malnourished | 21.9[c] | 14.6-34.5 | |
| Fat mass (kg) | Normal nutritional status | 26.5[a] | 21.2-33.3 | 0.001 |
| | At risk of malnutrition | 21.6[b] | 15.5-28.7 | |
| | Malnourished | 10.6[c] | 7.0-22.5 | |
| FMI (kg/m2) | Normal nutritional status | 10.3[a] | 7.9-13.1 | 0.001 |
| | At risk of malnutrition | 8.4[b] | 5.7-12.0 | |
| | Malnourished | 4.0[c] | 2.6-9.2 | |
| Fat free mass (kg) | Normal nutritional status | 50.6[a] | 44.7-56.9 | 0.001 |
| | At risk of malnutrition | 44.6[b] | 40.0-49.5 | |
| | Malnourished | 38.6[c] | 35.6-43.0 | |
| Muscle mass (kg) | Normal nutritional status | 48.3[a] | 42.5-54.3 | 0.001 |
| | At risk of malnutrition | 42.7[b] | 38.0-47.3 | |
| | Malnourished | 36.8[c] | 33.6-41.3 | |
| Total body water (%) | Normal nutritional status | 47.9[a] | 43.9-51.9 | 0.001 |
| | At risk of malnutrition | 49.8[b] | 44.5-55.0 | |
| | Malnourished | 57.0[c] | 48.0-62.4 | |
| Total body water (kg) | Normal nutritional status | 37.0[a] | 32.7-41.6 | 0.001 |
| | At risk of malnutrition | 32.7[b] | 29.3-36.3 | |
| | Malnourished | 28.3[c] | 26.1-31.5 | |
| BMR (kcal) | Normal nutritional status | 1496[a] | 1349-1676 | 0.001 |
| | At risk of malnutrition | 1319[b] | 1210-1458 | |
| | Malnourished | 1165[c] | 1050-1238 | |

*Data were analyzed using Kruskal Wallis test followed by pairwise comparison using the Mann Whitney test. P < 0.05 is considered statistically significant. Significant differences between groups are marked with superscript letters on the median values. Nutrition status was assessed using the mini-nutritional assessment (MNA®). BMI: body mass index, FMI: fat mass index; BMR: basal metabolic rate.*

## Discussion

Changes in body composition could have an adverse effect on the health and functional status of older adults (21,22). The current study showed that older women had significantly higher BMI, PBF, fat mass, and FMI compared to older men, while older men had significantly higher FFM, muscle mass, %TBW, and TBW compared to older women. These findings seem to be consistent with those of a study conducted among

**Table 5.** Binary logistic regression: the impact of body composition status on the odds ratio of being malnourished or at risk of malnutrition in comparison to normal nutritional status

| **Body composition (independent variable)** | **Model 1** OR (95% CI) | **P-value** | **Model 2** OR (95% CI) | **P-value** |
|---|---|---|---|---|
| BMI (kg/m2) | 0.86 (0.839-0.886) | 0.001 | 0.85 (0.82-0.87) | 0.001 |
| Body fat (%) | 0.96 (0.94-0.97) | 0.001 | 0.91 (0.89-0.93) | 0.001 |
| Fat mass (kg) | 0.93 (0.92-0.97) | 0.001 | 0.91 (0.90-0.93) | 0.001 |
| FMI (kg/m2) | 0.88 (0.85-0.91) | 0.001 | 0.82 (0.78-0.85) | 0.001 |
| Fat free mass (kg) | 0.90 (0.88-0.92) | 0.001 | 0.87 (0.85-0.89) | 0.001 |
| Muscle mass (kg) | 0.90 (0.88-0.91) | 0.001 | 0.86 (0.84-0.88) | 0.001 |
| MMI (kg/m2) | 0.66 (0.615-0.706) | 0.001 | 0.66 (0.61-0.71) | 0.001 |
| CC ≥ 31 cm | 0.071 (0.051-0.101) | 0.001 | 0.055 (0.037-0.082) | 0.001 |

**The reference category of the outcome is the risk of malnutrition or malnourished combined (vs. the well-nourished category). BMI = body mass index, FMI = fat mass index, MMI: muscle mass index, CC = calf circumference. All independent variables are continuous, except for calf circumference, which is dichotomized to < 31 cm vs. ≥ 31 cm, based on the form of the MNA. Model 1: crude model, Model 2: adjusted for age and sex, marital status, employment status (employed, not employed), monthly income, living arrangement (living alone vs. living with family member or others), dependency status (independent vs. dependent). OR = Odds ratio; CI = confidence interval. P < 0.05 is considered statistically significant. The Hosmer-Lemeshow test was used to assess the goodness of fit (P > 0.05).*

elderly persons living in Tehran, Iran, which showed that obesity, fat mass, PBF, and FMI were significantly higher in women than in men (23). Our results are also in agreement with those of the study conducted by Iqbal *et al.*, in Saudis aged 15–72 years, which showed that women had higher BMI, fat mass, and PBF compared to men (24). However, when Makizako *et al.* assessed BMI and other body composition parameters in older Japanese adults using BIA, they found that men had higher BMI compared to women (25). This difference in findings could be related to differences in women's lifestyle and activity levels between the two countries. However, they found fat mass to be higher in women and muscle mass to be higher in men; our findings are consistent with this.

We found that FFM, muscle mass, TBW, and BMR were significantly lower in the group aged ≥ 80 years compared to other age group categories. The decrease in FFM and muscle mass in the oldest age group could be related to sarcopenia, which can be diagnosed as low muscle mass with low muscle strength or performance (26). Kilic *et al.* showed that patients with sarcopenia had low skeletal muscle mass, measured using Quadscan and InBody body composition analyzers, and had low skeletal muscle index compared to non-sarcopenic patients (27). A study conducted by Shimado *et al.* on independently living Japanese older adults, found that muscle mass and BMR were lower in the group aged ≥ 80 years compared to other older age group categories (50–64 years and 65–74 years) in both men and women (28). In addition, they found grip strength, which gives an indication of physical and functional status in older adults, was lower in the oldest group compared to the other age groups and that grip strength was positively correlated with muscle mass.

Our study showed that the mean PBF in older men and women was 29.31 and 39.75 respectively, which were higher than the PBF cutoff values (≤ 24 for men and ≤ 36 for women) (29). Habib (30), using PBF cutoff values < 25 for men and < 35 for women, and Azzeh *et al.* (31), using PBF cutoff values ≤ 24 for men and ≤ 36 for women, have also shown that the mean PBF in both Saudi men and women exceeds the normal cutoff value, and that women have significantly higher PBF compared to men. The increase in PBF and the decrease in muscle mass have been associated with frailty in older adults. Falsarella *et al.* (32) have shown that frail older adults have greater PBF and lower muscle mass compared to non-frail older adults.

Furthermore, they found that handgrip strength was negatively associated with PBF and positively associated with muscle mass, while gait speed was positively associated with PBF and fat mass. Another recent prospective-cohort study conducted in community dwelling older adults (70–79 years old) examined the association of diet quality, using the healthy eating index, with 4 year incidence of frailty. Hengeveld and colleagues showed that among robust and pre-frail individuals, those consuming a poor quality diet had significantly higher frailty incidence than those consuming a good quality diet (Hazard ratio 1.92, CI 1.17-3.17) (33).

In the current study, those who were classified as MN had significantly lower BMI, PBF, fat mass, FFM, muscle mass, TBW, and BMR compared to those classified as RM or WN. Furthermore, those classified as RM had significantly lower BMI, PBF, fat mass, FFM, muscle mass, and TBW compared to the WN group. Thus, the study gives an indication of the relationship between anthropometric and nutrition status in older adults. It is likely that the lower body composition indicators are causally related to the poorer nutritional state, although this can only be an interpretation of the findings. In turn, these could result in poorer muscle strength and impaired mobility. These results and interpretations are consistent with data recently obtained by Chatindiara and colleagues (34) in community dwelling older New Zealander adults, using the short form of the MNA. They found that the odds for nutritional risk decreased not only with increasing values of FFM index (0.5; 95% CI, 0.34–0.77) but also with increasing PBF (0.81; 95% CI, 0.77–0.90). Schrader *et al*. (35) reported that the percentage of geriatric patients unable to perform the timed "up and go" test, a test that gives an indication of functional status, increased with the deterioration of nutritional status. After using multiple binary regression, adjusted for sex, age, disease severity, number of diagnosis, and cognitive function, they found that higher MNA score decreased the risk of being unable to perform activities of daily living by 15%.

Strengths of the current study are the sample size, the representation of older adults in Riyadh city, and the determination of multiple body composition indices. One of main limitations is that it is a cross sectional study, and so cannot determine a causal relationship among the variables. Prospective cohort studies are needed to highlight, in depth, the possible factors that affect the body composition of older adults. Another limitation of the study is that it only included older adults from Riyadh city, who may not represent older adults from rural regions of the KSA.

To conclude, there is a significant association between anthropometric measurements and nutritional status in older Saudi adults. Anthropometric assessment of older adults should be a routine practice in PHCCs, as it provides useful information that is related to the health status of older adults, particularly with respect to nutritional and functional status. Furthermore, the increasing evidence of a reduction in mortality risk with higher BMI in older adults (36) and the findings of the current study indicating an association between risk of developing malnutrition and several anthropometric measurements, highlight the necessity of developing anthropometric cutoff points for older adults in the KSA.

## Conflict of Interest

The authors have no conflicts of interest to declare.

## Ethical Approval

The study was approved by the Ethical Committee at the Ministry of Health, KSA (reference: 10S/72).

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