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Association between physical activity patterns and sarcopenia in Arab men

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Abstract

Objective: In this study, we aimed to examine the association between physical activity patterns and sarcopenia in Arab men.

Methods: This cross-sectional study included 363 men (47.7 ± 15.4 years). We analyzed appendicular lean mass (ALM), handgrip strength test, and physical activity levels. ALM divided by height (meters) squared was calculated (ALM/Ht^2), and participants with -1 and -2 standard deviations below the sex-specific mean for Saudi young adults were considered to have sarcopenia class I and class II, respectively. Independent *t*-tests, analysis of variance, and Mann–Whitney U tests were performed to determine mean and median differences.

Results: We observed a significant difference between participants with and without sarcopenia in moderate-to-vigorous physical activity (MVPA); the correlation between ALM/H^2 and MVPA was borderline significant. With a 1-hour/week increase in MVPA, ALM/Ht^2 increased by 0.30 kg/m^2. Total and ALM, handgrip strength, and MVPA were significantly lower in participants age $>$60 years; fat mass and waist circumference were unchanged as compared with middle-aged participants.

Conclusions: We identified an association between time spent in recreational MVPA and lean muscle mass among Arab men. Future studies should examine the role of MVPA training programs on muscle mass and strength in older men.

Keywords

Appendicular lean mass, handgrip strength, body fat, physical activity, sedentary, Arab men

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Introduction

Sarcopenia is a geriatric syndrome that has been classified as a muscular disease.[1] The occurrence of sarcopenia may be proportionally associated with an increase in fat mass and can progress differently in different individuals.[2] Obesity is associated with pathophysiological diseases and impairment of physical functions. Sarcopenic obesity has 2.6 higher odds of causing difficulty in climbing stairs.[3] Whereas no synergistic effect between body size and fat has been observed in some studies of sarcopenia,[4] Chang et al.[5] classified older participants according to their physical activity levels and found that obese older people with sarcopenia had worse physical performance than their normal-weight counterparts. Therefore, sarcopenic obesity seems to exert a synergistic impact on physical performance in older adults. Moreira et al.[6] also found that middle-aged women with sarcopenic obesity (7% of the participants) had significantly lower hand-grip strength, lower knee extension and flexion strength, and required a longer time to stand up from a chair compared with non-obese, non-sarcopenic women. Increased fat mass and decreased muscle mass are distinct factors associated with disability, immobility, and mortality.[7] Thus, markers of sarcopenic obesity should be monitored, and non-pharmacological preventive measures should be considered in older populations. Moreover, the onset of sarcopenia and pre-sarcopenia is associated with several changes in body composition, such as body mass index (BMI) and calf circumference.[8] It is important to compare the body composition of older people with that of middle-aged and younger populations, to determine the corresponding changes in the whole body composition, especially if there are no longitudinal studies in the same population.

Physical activity can reduce body fat mass, increase muscle mass and strength, and improve physical function. For example, increments of 1 hour/day in total physical activity and moderate-to-vigorous physical activity (MVPA) are inversely associated with body fat mass, BMI, and waist circumference (WC) and positively associated with increased lower limb muscle strength.[9] Engagement in regular daily physical activity is an effective strategy to prevent sarcopenia.[10] The association between daily physical activity measured using an accelerometer and the occurrence of sarcopenia, was examined among older Japanese individuals in a 1-year study; the results showed that walking 7,000 to 8,000 steps/day and/or engaging in an activity that achieved >3 metabolic equivalents (METs) for 15 to 20 minutes/day were likely to prevent a reduction of muscle mass.[11] Replacing sedentary time with 15 or 60 minutes of MVPA can lower the risk of sarcopenia by approximately 15% and 50%, respectively.[12] It was found that community-dwelling older men spent 2.5 hours/day engaged in physical activity, but only 10% of this time was at the MVPA level. These daily activities were found to be associated with a reduced risk of sarcopenia and increased levels of physical function,[13] suggesting the importance of even low physical activity (LPA). Total physical activity and MVPA have an inverse association with sarcopenia; however, no significant relationship has been observed with LPA.[9] Therefore, the intensity and duration of daily physical activity could play an important role in reducing the occurrence of sarcopenia.

Handgrip strength (HGS) is an indicator of muscle strength. HGS <30 kg in men is a risk factor of sarcopenia[14] and has recently been suggested as the first marker of sarcopenia or probable sarcopenia. Recently, a new cut-off of 27 kg for HGS in men has been recommended.[15] However, an association between HGS and physical activity has not yet been established. For example, in a cross-sectional study among older men, the highest tertile of LPA was associated with greater HGS whereas no association was noted with sedentary time.[16] In a different study, an association between physical activity and HGS in older individuals age >75 years was not found.[13] A recent review suggested that most studies have identified an association between exercise intervention and muscle mass, but muscle strength required specific types of physical activity.[10] Most studies on sarcopenia in Asia were conducted in East Asia; thus, there is a need for data from South and Southwest Asia.[17] Thus, the main aim of this study was to examine the association between physical activity patterns and the markers of sarcopenia (muscle mass and strength) in Arab men. The secondary aim was to investigate the interaction between age and obesity and lean muscle mass as a marker of pre-sarcopenia.

Methods

Participant characteristics

This study comprised men who completed all necessary tests, including Saudi nationals and men of different Middle Eastern nationalities living in Saudi Arabia. Recreationally active people who engaged in regular exercise ≥3 times/week were included, provided that they were not professional athletes. Exclusion criteria were men with BMI >40 kg/m^2, diagnosis of an illness that affected muscle mass (i.e., muscle wasting owing to another disease or treatment), and inability to move naturally (e.g., recovery from injury and chronic fatigue syndrome).

Based on the Statistical Saudi Population Survey 2018, the population in Riyadh City is 8,002,100; of the total, 42.7% are non-Saudis and approximately 23% of these are Arabs, with the highest proportion from Egypt followed by Yemen.[18] Men age >20 years represent 41.6% of the Saudi population, such that men in Riyadh City total 3,416,896, including 1,459,014 Saudis and 450,312 non-Saudi Arabs. Thus, the population of Saudi and non-Saudi Arab men age >20 years is 1,909,326. With a 95% confidence level and 5% margin of error, the confidence interval is 4.45, and the required sample size for the current descriptive epidemiological study is 384 men.[19]

Study procedure

This study had a cross-sectional design. Announcements regarding recruitment of voluntary study participants and the aim and procedure of data collection were sent to relevant communities and groups and were posted on social media. The first stage of recruitment was to screen interested participants who telephoned and request them to come to the selected location for data collection. Data collection locations were as follows: for men age <40 years, data were collected at the College of Sport Sciences and Physical Activity at King Saud University (KSU), Riyadh, Saudi Arabia; for men age >40 years, data were collected at different Community Development Commissions of the districts of Riyadh (two in the South districts, one in the East districts, one in the Central districts, two in the North districts, and one in a town near Riyadh City). These commissions contributed to the study by contacting the population in the community, as well as hosting data collection. The age of participants ranged between 20 and 80 years; our participants well represented the male population of the city of Riyadh in Saudi Arabia. The participants were divided into three age groups: older (>60 years), middle-aged (40–60 years), and younger (<40 years). All data were included in the analysis.

Participants were instructed to arrive at the data collection locations in the morning before eating breakfast. Written informed consent was provided by all participants. Measurements included anthropometry, body composition using bioelectrical impedance analysis, an HGS test, and physical activity assessment using the Global Physical Activity Questionnaire (GPAQ), Arabic version.

Measurements

Participants' height was measured to the nearest 0.1 cm using a stadiometer (Seca 213; Seca GmbH & Co., Hamburg, Germany), and body weight was measured to the nearest 0.1 kg using a digital scale (Detecto ProDoc PD100 Scale; Cardinal Scale Manufacturing Company, Webb City, MO, USA). WC was measured at the umbilicus to the nearest 0.1 cm using a measuring tape. Resting heart rate and systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mmHg) were measured using an automatic arm digital sphygmomanometer (Omron HEM-7121; Omron Healthcare Co. Ltd., Kyoto, Japan).

Total body composition was measured using a Tanita MC-980MA (Tanita Corporation, Tokyo, Japan), a multi-frequency segmental machine that delivers currents of 50 to 1000 kHz. Body composition, including fat mass and appendicular lean mass (ALM), was determined from the output, as per the recommended protocols. ALM was divided by the square of height, in meters (Ht^2). In the current study, we used different local and global cut-off values of ALM/Ht^2 to classify participants with sarcopenia.[14] These cut-off values included the European Working Group on Sarcopenia in Older People 2010 (EWGSOP1) definition for sarcopenia (pre-sarcopenia) at 7 kg/m^2,[14] the European Working Group on Sarcopenia in Older People 2018 (EWGSOP2) definition for sarcopenia (confirmed sarcopenia) at 7.26 kg/m^2,[15] and the definition for pre-sarcopenia of a value of 1 standard deviation (SD) (class I) and 2 SD (class II) below the mean of the local reference value for young Saudi men, at 8.6 kg/m^2 and 7.4 kg/m^2, respectively.[20]

Participants with sarcopenia were divided into obese and non-obese groups to examine sarcopenic obesity, then further divided into groups with and without abdominal obesity, to investigate sarcopenic abdominal obesity. Obesity was determined using fat percentage 25% of body weight, and abdominal obesity was determined as a WC of 102 cm.[21] The fat mass index (FMI) is the total body fat mass divided by Ht^2 in meters, and the fat-free mass index (FFMI) is the total lean mass divided by Ht^2 in meters.

HGS was measured in the dominant hand using a manual spring dynamometer (Baseline® Smedley Spring Dynamometers, Fabrication Enterprises Inc., NY, USA); the best of two measurements was recorded, in kilograms. Participants were subdivided into three groups, as follows: group 1 with HGS >42 kg, which is the median HGS of 471 Arab men in a recent study;[22] group 2 with HGS <30 kg, which is the lower level of HGS based on the EWGSOP1 cut-off; and group 3 with HGS 30 to 42 kg, which is higher than the risk of low HGS (HGS $\geq$30 kg) but <50% in the same population (HGS $\leq$42 kg).

A written version of the Arabic GPAQ was completed by all participants under the supervision of the research assistant, who explained the questionnaire and answered queries. The GPAQ is divided to four domains: MVPA at work, recreational MVPA ($MVPA_{recreational}$), travel to and from locations, and sedentary behavior. Questions include the time spent in each domain/day and the frequency/week.[23] In the current study, 62% of participants did not engage in any MVPA at work; hence, only $\text{MVPA}_{\text{recreational}}$ was used in the MVPA analysis.

Ethical considerations

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (King Saud University, IRB no. E-18-3381) and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Statistical analysis

Statistical analysis was performed using IBM SPSS, version 21 (IBM Corp., Armonk, NY, USA). Continuous data are presented as mean ± SD for normal variables. Non-normal variables are presented as median (25th–75th) percentiles. All continuous variables were checked for normality using the Kolmogorov–Smirnov test. Non-normal variables were log-transformed. Frequencies and percentages were used for categorical variables. We used the independent *t*-test, analysis of variance, Mann–Whitney U-test, and Friedman test to determine the mean and median differences in normal and non-normal variables. Simple regression and correlation analyses were performed, and a p-value <0.05 was considered significant.

Results

This study included 363 men (age, 47.7 ± 15.4 years; BMI, 28.3 ± 5.2 kg/m^2; fat percentage, 27.1% ± 7.2%). Participants comprised 283 Saudi nationals and 80 men of different nationalities who were living in Saudi Arabia. Descriptive data showed that whereas body composition and HGS were normally distributed with coefficient of variation (CV) between 10% and 25%, LPA and MVPA were not normally distributed, with a CV between 34% and 32%, respectively. Medians and 25th to 75th percentiles are reported in the tables.

Participants were divided into sarcopenic and non-sarcopenic groups based on EWGSOP1 and EWGSOP2 cut-off values and the difference relative to the mean value of regional sex-specific populations (class $\text{I} = -1$ SD and class $\text{II} = -2$ SD). Table 1 shows the differences between participants with low and normal ALM/Ht^2 with respect to age, body weight, body fat, and HGS for all four cut-off values used in the study.

The presence of significant differences between participants with low and normal ALM/Ht^2 with respect to physical activity levels were affected by the cut-off values. For example, there was a significant difference between participants with low and normal ALM/Ht^2 in relation to $\text{MVPA}_{\text{recreational}}$ only when using the EWGOSP2 cut-off, which is the lower cut-off level (ALM/Ht^2 >7 kg/m^2) versus other threshold values of ALM/Ht^2. The difference between participants with low and normal ALM/Ht^2 was borderline significant when using the EWGOSP1 cut-off. In contrast, there was no significant difference between participants with low and normal ALM/Ht^2 for LPA when using EWGOSP1 or EWGOSP2, whereas the reference cut-off for Saudi men showed significant differences between groups based on −1 SD ($P = 0.01$) and −2 SD ($P = 0.001$). The median values of LPA were greatly increased in the low and normal ALM/Ht^2 groups when using −2 SD; with this cut-off value, many participants with low LPA levels were categorized in the low ALM/Ht^2 group. Last, there was no significant difference between participants with low and normal ALM/Ht^2 for sedentary behavior, regardless of the sarcopenia cut-off classification. The median values for sedentary behavior were larger between the

Table 1. Clinical characteristics of participants based on different ALM/Ht^2 cutoffs.

	EWGSOP2			EWGSOP1			2 SD < reference values for Saudi men			1 SD < reference values Saudi men		
	ALM/Ht^2 >7 kg/m^2			ALM/Ht^2 >7.26 kg/m^2			ALM/Ht^2 >7.4 kg/m^2			ALM/Ht^2 >8.6 kg/m^2		
Parameters	Normal	Low		Normal	Low		Normal	Low		Normal	Low	
N	341 (93.9)	22 (6.1)	P-value	323 (89.0)	40 (11.0)	P-value	313 (86.3)	50 (13.8)	P-value	194 (53.4)	169 (46.6)	P-value
Age (years)	47.2 ± 15.2	55.818.1	**0.011**	46.9 ± 14.9	53.9 ± 18.4	**0.008**	46.8 ± 14.8	53.9 ± 18.6	**0.002**	44.9 ± 13.3	50.9 ± 17.2	**<0.001**
Height (cm)	168.5 ± 6.8	168.8 ± 6.1	0.839	168.6 ± 6.9	167.3 ± 6.1	0.242	168.7 ± 6.9	167.0 ± 6.2	0.107	169.2 ± 7.0	167.6 ± 6.4	0.031
Weight (kg)	81.1 ± 13.1	61.9 ± 10.9	**<0.001**	82.2 ± 13.5	62.1 ± 94	**<0.001**	82.6 ± 13.4	63.1 ± 9.1	**<0.001**	87.9 ± 12.9	70.8 ± 10.2	**<0.001**
BMI (kg/m^2)	28.6 ± 4.7	21.7 ± 3.7	**<0.001**	28.9 ± 4.6	22.2 ± 3.5	**<0.001**	29.1 ± 4.6	22.7 ± 3.5	**<0.001**	30.8 ± 4.3	25.3 ± 2.9	**<0.001**
Fat mass (kg)	22.9 ± 9.1	15.5 ± 9.5	**<0.001**	23.4 ± 8.9	12.2 ± 8.6	**<0.001**	23.5 ± 8.9	15.8 ± 8.2	**<0.001**	25.8 ± 9.1	18.7 ± 7.8	**<0.001**
FFM (kg)	58.4 ± 7.7	46.3 ± 3.6	**<0.001**	59.0 ± 7.4	46.9 ± 3.4	**<0.001**	59.3 ± 7.3	47.4 ± 3.6	**<0.001**	62.6 ± 6.7	52.0 ± 5.3	**<0.001**
FMI (kg/m^2)	8.1 ± 3.3	5.7 ± 3.2	**0.001**	8.3 ± 3.2	5.6 ± 3.1	**<0.001**	8.3 ± 3.2	5.8 ± 2.9	**<0.001**	9.1 ± 3.2	6.7 ± 2.9	**<0.001**
FFMI (kg/m^2)	19.6 ± 1.9	15.4 ± 1.0	**<0.001**	19.7 ± 1.9	16.2 ± 2.2	**<0.001**	19.8 ± 1.8	16.3 ± 2.1	**<0.001**	20.8 ± 1.5	17.6 ± 1.6	**<0.001**
ALM/Ht^2 (kg/m^2)	8.9 ± 1.2	6.5 ± 0.5	**<0.001**	9.03 ± 1.2	6.8 ± 0.5	**<0.001**	9.1 ± 1.1	6.9 ± 0.5	**<0.001**	9.7 ± 1.0	7.7 ± 0.6	**<0.001**
HGS (kg)	39.1 ± 8.8	30.0 ± 8.5	**<0.001**	39.4 ± 8.6	31.6 ± 9.6	**<0.001**	39.6 ± 8.6	31.2 ± 8.9	**<0.001**	41.2 ± 8.5	35.3 ± 8.7	**<0.001**
MVPA$_{recreational}$ (minutes/week)	180 (0.0–480)	60 (0.0–210)	**0.039**	180 (0.0–480)	75 (0.0–270)	0.060	180 (0.0–480)	95 (0.0–280)	0.125	180 (0.0–540)	150 (0.0–360)	0.410
LPA (minutes/week)	90 (0.0–240)	20 (0.0–140)	0.104	90 (0.0–240)	45 (0.0–210)	0.104	100 (0.0–250)	15 (0.0–180)	**0.018**	140 (0.0–360)	50 (0.0–180)	**<0.001**
Sedentary (hours/day)	4.0 (3.0–6.3)	5.0 (4.0–8.0)	0.077	4 (3.0–6.5)	5 (4.0–6.0)	0.100	4.0 (3.0–6.75)	4.75 (4.0–6.0)	0.141	4.0 (3.0–6.5)	4.0 (3.0–6.5)	0.786

Notes: Data presented as mean ± SD and median (1st–3rd) percentiles for normal and non-normal variables.

P-values significant at 0.05 and 0.01 levels.

EWGSOP: European Working Group of Sarcopenia in Older People; SD: standard deviation; BMI: body mass index; FFM: fat-free mass; FMI: fat max index (fat mass/height^2); FFMI: fat-free mass index (fat-free mass/height2); ALM: appendicular lean mass; Ht^2: height in meters squared; HGS: handgrip strength; MVPA$_{recreational}$: recreational moderate-to-vigorous physical activity; LPA: light physical activity.

groups when using the EWGOSP2 cut-off but did not approach significance.

As seen in Table 2, 17.9% of participants had HGS <30 kg. There were significant differences between the groups with respect to age, FFM, and ALM/Ht^2 whereas there were no significant differences between the groups for BMI, body fat mass, and FMI. The differences between HGS groups in MVPA$_{recreational}$ approached borderline significance. Both groups with HGS >30 kg spent a greater amount of time engaged in LPA, and these differences were significant as compared with the third group, which had the lowest HGS ($P<0.01$). Sedentary behavior was similar among all groups, with no significant differences.

Table 3 shows that participants age >60 years had significantly lower height, muscle mass, and strength, and the values for body weight and fat in the age group 40 to 60 years were the highest in comparison with other age groups (younger and older men). Physical activity showed different patterns in relation to age group. For example, younger (<40 years) and middle-aged (40–60 years) men spent significantly more time engaged in MVPA$_{recreational}$ than older men (>60 years) ($P<0.001$) whereas middle-aged men spent a greater amount of time engaged in LPA than did younger and older men ($P=0.02$). There were no significant differences among age groups with respect to sedentary behavior.

Table 2. Clinical characteristics of participant subgroups based on different handgrip strength reference values.

	Handgrip strength (kg)			
Parameters	<30	30–42	>42	
N	65	179	119	P-value
Age (years)	61.5 ± 14.5	48.7 ± 14.8^{a}	40.9 ± 12.6^{a,b}	**<0.001**
Height (cm)	164.9 ± 6.2	166.8 ± 6.1	172.6 ± 6.1^{a,b}	**<0.001**
Weight (kg)	73.6 ± 12.5	78.1 ± 14.2	85.5 ± 14.0^{a,b}	**<0.001**
BMI (kg/m^2)	27.1 ± 4.7	28.1 ± 5.1	28.7 ± 4.6	0.180
SBP (mmHg)	129.3 ± 19.4	123.5 ± 17.5	118.5 ± 16.7^{a,b}	**0.002**
DBP (mmHg)	73.7 ± 12.3	76.6 ± 11.9	76.0 ± 11.4	0.335
HR$_{rest}$ (beats/min)	72.3 ± 13.2	68.1 ± 11.4	68.8 ± 12.8	**0.109**
Fat mass (kg)	21.4 ± 8.4	22.1 ± 8.9	23.4 ± 9.7	0.319
FFM (kg)	51.9 ± 6.7	56.0 ± 7.1^{a}	62.7 ± 7.5^{a,b}	**<0.001**
FMI (kg/m^2)	8.1 ± 3.0	8.0 ± 3.2	7.9 ± 3.4	0.960
FFMI (kg/m^2)	18.3 ± 2.6	19.2 ± 2.2^{a}	19.9 ± 1.9^{a,b}	**<0.001**
ALM/Ht^2 (kg/m^2)	7.9 ± 1.2	8.7 ± 1.2^{a}	9.3 ± 1.3^{a,b}	**<0.001**
MVPA$_{recreational}$ (minutes/week)	75 (0.0–420)	120 (0.0–420)	232.5 (0.0–505)	0.077
LPA (minutes/week)	10 (0.0–140)	105 (0.0–210)^{a}	102.5 (5.0–300)^{a}	**0.008**
Sedentary (hours/day)	4.0 (3.0–6.0)	4.0 (3.0–6.03)	4.5 (3.0–7.0)	0.966

Notes: Data presented as mean ± SD and median (1st–3rd) percentiles for normal and non-normal variables.

[a] Bonferroni post-hoc test, significant with respect to the group <30 kg.

[b] Bonferroni post-hoc test, significant with respect to the group 30–42 kg.

P-values significant at 0.05 and 0.01 levels.

BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR$_{rest}$: resting heart rate; FFM: fat-free mass; FMI: fat max index (fat mass/height^2); FFMI: fat-free mass index (fat-free mass/height^2); ALM: appendicular lean mass; Ht^2: height in meters squared; MVPA$_{recreational}$: recreational moderate-to-vigorous physical activity; LPA: light physical activity.

Table 3. Clinical characteristics of participants based on age.

	Age subgroups (years)			
Parameters	<40	40–60	>60	
N	121	143	99	P-value
Height (cm)	170.8 ± 6.4	168.8 ± 6.9	165.2 ± 5.7^{a,b}	**<0.001**
Weight (kg)	78.4 ± 18.2	85.1 ± 13.2^{a}	75.8 ± 12.7^{b}	**<0.001**
WC (cm)	81.3 ± 24.6	95.8 ± 18.7^{a}	93.9 ± 19.7^{a}	**<0.001**
BMI (kg/m^2)	26.9 ± 5.9	29.9 ± 4.6^{a}	27.8 ± 4.5^{b}	**<0.001**
SBP (mmHg)	111.3 ± 12.8	124.6 ± 18.9^{a}	131.2 ± 19.6^{a,b}	**<0.001**
DBP (mmHg)	72.4 ± 10.4	77.8 ± 12.3^{a}	77.4 ± 11.8^{a}	**<0.001**
HR$_{rest}$ (beat/min)	67.7 ± 11.6	68.1 ± 12.8	71.6 ± 11.9^{a}	**0.04**
HGS (kg)	41.8 ± 7.9	40.1 ± 8.3	32.1 ± 8.3^{a,b}	**<0.001**
Fat mass (kg)	19.9 ± 10.8	25.4 ± 8.6^{a}	21.9 ± 8.0^{b}	**<0.001**
FFM (kg)	58.6 ± 8.5	59.9 ± 7.3	53.4 ± 6.7^{a,b}	**<0.001**
FMI (kg/m^2)	6.8 ± 3.6	8.9 ± 3.2^{a}	8.0 ± 2.9^{a}	**<0.001**
FFMI (kg/m^2)	19.0 ± 2.6	19.9 ± 1.9^{a}	18.6 ± 2.1^{b}	**<0.001**
ALM/Ht^2 (kg/m^2)	9.0 ± 1.4	9.1 ± 1.2	8.1 ± 1.1^{a,b}	**<0.001**
MVPA$_{recreational}$ (minutes/week)	210 (0.0–510)	200 (0.0–540)	80 (0.0–215)^{a,b}	**0.001**
LPA (minutes/week)	70 (0.0–240)	140 (0.0–300)	60.0 (0.0–180)^{b}	**0.022**
Sedentary (hours/day)	5.0 (3.0–7.0)	4.0 (3.0–7.0)	4.0 (3.0–6.0)	0.946

Notes: Data presented as mean ± SD and median (1st–3rd) percentiles for normal and non-normal variables.

P-values significant at 0.05 and 0.01 levels. A and B represent Bonferroni post-hoc tests significant with respect to ages <40 years and 40–60 years, respectively.

BMI: body mass index; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR$_{rest}$: resting heart rate; FFM: fat-free mass; FMI: fat max index (fat mass/height^2); FFMI: fat-free mass index (fat-free mass/height^2); ALM: appendicular lean mass; Ht^2: height in meters squared; HGS: handgrip strength; MVPA$_{recreational}$: recreational moderate-to-vigorous physical activity; LPA: light physical activity.

Table 4 shows the difference between obese and non-obese participants who had sarcopenia based on the Saudi cut-off values for class 1 (ALM/Ht^2 = 7.4 kg/m^2, n = 50) and class 2 (ALM/Ht^2 = 8.6 kg/m^2, n = 169). Additionally, the differences between participants with and without sarcopenic abdominal obesity were analyzed based on class 2 because only five participants were classified as abdominally obese when using the class 1 cut-off. Muscle mass was significantly higher in obese participants with class 1 sarcopenia, and SBP was also significantly increased with excess body fat. The significant difference in HGS between obese and non-obese participants with sarcopenia approached borderline when using the −2 SD Saudi reference cut-off (P = 0.054) whereas there was no significant difference between the group when using the −1 SD Saudi reference value. There were no significant differences between obese and non-obese participants with sarcopenia and between participants who had sarcopenia with and without abdominal obesity in all physical activity patterns, including MVPA$_{recreational}$, LPA, and sedentary behavior.

Figure 1 shows the correlation between MVPA$_{recreational}$ and ALM/Ht^2, after excluding individuals who did not engage in MVPA (n = 238); there was no significance in the correlation between LPA and ALM/Ht^2.

Discussion

In the current study, we aimed to examine the association between physical activity

Table 4. Comparison of obese and non-obese participants with sarcopenia for the study variables.

	ALM/Ht^2 >7.4			ALM/Ht^2 >8.6			ALM/Ht^2 >8.6		
Parameters	Sarcopenia, non-obese	Sarcopenia, obese		Sarcopenia, abdominally non-obese	Sarcopenia, abdominally obese		Sarcopenia, non-obese	Sarcopenia, obese	
N	33	17	P-value	136	33	P-value	86	83	P-value
Age (years)	49.9 ± 20.6	60.8 ± 9.9	0.053	49.1 ± 17.6	58.4 ± 13.1	**0.005**	45.0 ± 19.1	57.0 ± 12.3	**<0.001**
SBP (mm Hg)	116.8 ± 18.9	121.4 ± 33.1	0.537	119.8 ± 21.5	131.4 ± 15.8	**0.004**	116.8 ± 18.1	127.7 ± 22.4	**0.001**
DBP (mm Hg)	67.8 ± 11.3	71.8 ± 17.4	0.342	74.1 ± 12.3	74.3 ± 11.6	0.913	71.6 ± 10.2	76.8 ± 13.5	**0.005**
HR_{rest} (beats/min)	66.9 ± 12.9	67.7 ± 15.8	0.855	68.1 ± 12.5	68.1 ± 11.8	0.983	66.3 ± 11.9	70.0 ± 12.6	0.052
FMI (kg/m^2)	4.0 ± 1.2	9.1 ± 2.6	**<0.001**	5.8 ± 1.2	10.4 ± 2.9	**<0.001**	4.5 ± 1.3	8.9 ± 2.3	**<0.001**
FFMI (kg/m^2)	16.2 ± 2.8	16.1 ± 1.0	0.933	17.4 ± 1.8	18.0 ± 1.2	0.08	17.2 ± 2.1	18.0 ± 1.3	**0.004**
ALM/Ht^2 (kg/m^2)	6.9 ± 0.5	6.9 ± 0.4	0.787	7.7 ± 0.7	7.9 ± 0.5	0.074	7.6 ± 0.7	7.8 ± 0.6	**0.014**
HGS (kg)	32.8 ± 9.8	28.6 ± 6.1	0.126	35.4 ± 8.5	34.7 ± 9.3	0.700	36.5 ± 8.5	33.9 ± 8.7	0.054
$MVPA_{recreational}$ (minutes/week)	60 (0.0–280)	190 (0.0–277)	0.611	145 (0.0–345)	210 (84–360)	0.312	130 (0.0–420)	180 (5.0–300)	0.661
LPA (minutes/week)	20 (0.0–140.0)	0.0 (0.0–210)	0.847	55 (0.0–180)	20 (0.0–175)	0.735	37.5 (0.0–160)	70 (0.0–210)	0.608
Sedentary (hours/day)	5.0 (4.0–6.0)	4.0 (4.0–6.0)	0.381	4.0 (3.0–6.0)	5.5 (3.0–7.0)	0.874	4.0 (3.0–6.0)	4.0 (3.0–6.8)	0.598

Notes: Data presented as mean ± SD and median (1st–3rd) percentiles for normal and non-normal variables.

P-values significant at 0.05 and 0.01 levels.

WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR_{rest}: resting heart rate; FMI: fat max index (fat mass/height^2); FFMI: fat-free mass index (fat-free mass/height^2); ALM: appendicular lean mass; Ht^2: height in meters squared; HGS: handgrip strength; $MVPA_{recreational}$: recreational moderate to vigorous physical activity; LPA: light physical activity.

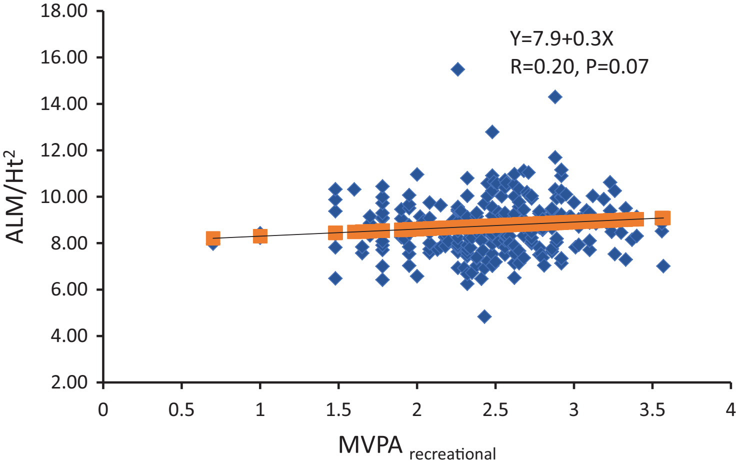

Figure 1. Correlation of recreational moderate to vigorous physical activity ($MVPA_{recreational}$) with appendicular lean mass over square of height in meters (ALM/Ht^2). With a 1-hour increase per week in $MVPA_{recreational}$, ALM/Ht^2 increased 0.30 kg/m^2 (n = 238).

patterns, including $MVPA_{recreational}$, LPA, and sedentary activity, and indicators for sarcopenia including muscle mass and strength. We also investigated the role of age, fat mass, and abdominal fat in sarcopenia and its relationship with physical activity. We found an association between $MVPA_{recreational}$ and muscle mass; along with muscle strength,. These factors were significantly lower in participants age >60 years whereas there was no change in fat mass. LPA was significantly higher in participants without sarcopenia when using Saudi reference values, and weak HGS was correlated with low levels of LPA and $MVPA_{recreational}$. The findings of the current study suggest interactive effects between physical activity and markers of sarcopenia.

Individuals with sarcopenia were older and had lower body weight, body fat mass, and HGS. One study reported that individuals with sarcopenia had lower weight, BMI, fat mass, and muscle strength and showed poor performance in four of six physical performance tests.[24] As shown in Table 1 and Figure 1, the current findings collectively suggest an interactive relationship between ALM/Ht^2 and $MVPA_{recreational}$. This was in agreement with a previous study reporting that MVPA was associated with increased muscle mass and strength.[12] Older individuals who engaged in more MVPA were found to have a lower likelihood of developing sarcopenia as compared with the least active participants in the study. The former individuals also had greater HGS and faster walking speed.[25] A study reported that individuals who walked <5,300 steps/day and/or spent <15 minutes/day at >3 METs were 2.00 to 2.66 and/or 2.03 to 4.55 times more likely to have sarcopenia, respectively, when compared with those who walked >7,800 steps/day and/or spent >23 minutes/day at >3 METs.[11]

As expected, the current data showed a strong association between muscle mass and strength, as measured with ALM/Ht^2 and HGS. HGS was significantly lower with increased age, and participants age >60 years showed an average HGS of 32.1 kg, similar to that of their peers in previous studies conducted among older

Saudi[26] and Asian[27] men. Increased HGS was associated with increased LPA and $\mathrm{MVPA}_{\mathrm{recreational}}$, particularly at the cut-off threshold of 30 kg, and HGS and $\mathrm{MVPA}_{\mathrm{recreational}}$ were lower in participants >60 years of age. The association among cardiorespiratory fitness, HGS, and physical activity has previously been studied among 67,702 participants in the UK Biobank, and all-cause mortality and cardiovascular disease were assessed in the follow-up period. The hazard ratio of mortality associated with lower physical activity was highest among participants in the lower tertile of HGS and the lowest among those in the highest tertile of HGS; this interaction was not found with cardiorespiratory fitness.[28] The UK Biobank data also showed that adiposity and HGS at baseline predicted patterns of physical activity in the 5-year follow-up period and that MVPA was lower in the lowest HGS quintile than that in the highest quintile across all BMI categories, indicating that improving body composition and muscle strength can help to enhance active living and increase MVPA.[29] The Lifestyle Interventions and Independence For Elders Study showed that the highest intensity of LPA was associated with greater HGS, but sedentary behavior was not associated with HGS.[16] Another study reported that middle- and old-aged adults in the highest quartile of MVPA were stronger (by 1.84 kg) than their peers in the lower quartile, based on HGS measurements.[30] It is notable that muscle strength independently influenced mortality to a greater extent than muscle mass in an older cohort,[31] and the hazard ratio of mortality was 1.67 in a comparison of the highest and lowest quartiles of HGS, based on 14 studies in older populations.[32] Therefore, handgrip weakness in older adults could predict disability.[33]

In the current findings, whereas height was not associated with muscle mass, there was a significant difference between HGS groups in terms of their average height and weight. A recent study confirmed that the anthropometric measure of height had a high correlation with HGS,[34] and another study found that height and weight were correlated with HGS.[27] Although BMI had a significant correlation with HGS among Saudi adult men, in stepwise multiple linear regression, BMI was excluded and only hand length, forearm circumference, and age were selected.[35] The current data showed that obese participants with sarcopenia had lower HGS than their non-obese counterparts, which approached borderline significance at one threshold used in this study.

There were no differences in physical activity patterns between obese and non-obese participants with sarcopenia, and there was an association between increased fat mass and increased SBP. Thus, it is important to evaluate the association between fat mass and health aspects rather than physical activity alone. For example, sarcopenia and adiposity can increase blood pressure and can synergistically induce hypertension; thus sarcopenic obesity is a strong independent factor of hypertension.[36] Generally speaking, previous studies have suggested that sarcopenic obesity is associated with low physical activity,[37] and engagement in physical activity can contribute to reducing the risk of sarcopenic obesity.[38]

The current study can help to improve understanding of the status of sarcopenia and physical activity among middle-aged and older men of Arab ethnicity in the region of Southwest Asia. Our findings can serve as a reference for local and international values of sarcopenia. The primary limitations of this study were that we used a self-reported physical activity questionnaire; these data could have been inaccurately reported by study participants. It should be noted that GPAQ includes only one question on the duration of sedentary activity; different types of sedentary behavior, such as watching television, reading, and computer use, might have different associations and outcomes.[16] Future studies should include women as well as all countries in the region, to provide a more comprehensive view of how the factors investigated herein are linked.

To summarize, younger and middle-aged male adults who were stronger and had normal weight preferred to engage in $\mathrm{MVPA}_{\mathrm{recreational}}$ whereas older men preferred LPA. Sedentary activity levels showed no interactive correlations with the current study variables. Although increased fat mass was associated with increased muscle mass, it had a negative correlation with DBP. The relationship between sarcopenic obesity and physical activity was not different from the relationship between sarcopenia alone and physical activity in the current study. Whereas fat mass did not change for older participants as compared with younger and middle-aged participants, muscle mass was significantly lower among older participants.

Conclusion

$\mathrm{MVPA}_{\mathrm{recreational}}$ had a borderline association with muscle mass. Independent of the total and abdominal fat mass, muscle mass was lower in older men, who preferred engaging in LPA than middle-aged and young men, who preferred engaging in $\mathrm{MVPA}_{\mathrm{recreational}}$. Future studies should be conducted to examine the role of MVPA training programs on muscle mass in older men.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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