Submitted: 23 October, 2019 Accepted: 28 September, 2020 Published: 08 January, 2021 DOI:10.31083/jomh.v17i1.200

JOMH Journal of Men's Health

Original Article

Differences in physical function and metabolic syndrome risk factors according to the level of physical activity in elderly Korean men: a pilot study

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Abstract

Background and objective: Managing the decrease in physical function in the elderly is a major task in aging societies globally. Here, we aimed to compare the physical function and metabolic syndrome (MetS) risk factors according to levels of physical activity (PA). **Material and methods**: We measured PA in 77 elderly Korean men (74.21 $\pm$ 6.26 years old) with an accelerometer and recorded body composition, physical function, and MetS-related risk factors. Participants were divided into three groups based on daily moderate-vigorous physical activity (MVPA): low (under 60 min), middle (60-120 min), and high (over 120 min). The groups were compared using a one-way analysis of variance and the Scheffe post hoc test. Odds ratios (OR) were calculated by logistic regression analysis. **Results**: Significant differences were found between the groups for sedentary behavior time ($P < 0.001$), light PA ($P < 0.05$), moderate PA ($P < 0.001$), vigorous PA ($P < 0.05$), and total energy expenditure ($P < 0.001$). The high PA group showed a significantly lower percentage of body fat and fat mass and higher muscle mass than did the low and middle PA groups ($P < 0.05$). The 6-min walk test was significantly better in the high PA group than in the low and middle PA groups ($P < 0.05$). Grip strength and the Berg balance scale were also significantly better in the high PA group ($P < 0.05$). Bone mineral density (BMD) and high-density lipoprotein cholesterol (HDL-C) were significantly higher in the high PA group than in the low PA group ($P < 0.05$). Systolic blood pressure (SBP) was significantly higher in the middle PA group than in the low PA group ($P < 0.05$). Participants with more than three MetS criteria showed an OR of 0.09 (95% confidence interval 0.01-0.82) in the high PA group as compared with the low PA group ($P < 0.05$). **Conclusions**: Moderate-vigorous physical activity of more than 120 min daily showed better physical function and lower OR of MetS than did lower MVPA levels in elderly Korean men.

Keywords

Elderly; Metabolic syndrome; Physical activity; Physical fitness

1. Introduction

The population of the elderly is growing globally at an accelerated pace [1]. The Republic of Korea became an aging society in 2017 when the ratio of the elderly exceeded 14% and is expected to become a super-aged society with more than 20% of the elderly in 2025 [2]. It is reported that the elderly experience a rapid change in their physical function with aging [3]. In the Republic of Korea, 51% of the elderly over 65 years have more than three comorbidities and 22% have more than two comorbidities [4]. The common comorbidities in the elderly are diabetes, cardiovascular disease, overweight, and obesity, all of which are closely related to metabolic syndrome (MetS) [5].

In the process of aging, metabolic and cardiovascular function declines, resulting in an increased incidence of MetS that includes obesity, abnormal glucose metabolism, hypertension, and hyperlipidemia [6, 7]. However, these MetS-related factors can be improved by physical activity (PA) [8]. Regular PA helps to increase energy expenditure, which is related to weight reduction and improvements in serum glucose, blood pressure, and blood lipid metabolism by supporting carbohydrate and fat catabolism [9]. High levels of cardiorespiratory fitness (CRF) show an inverse correlation with the prevalence of MetS [10]. Hence, regular PA is recommended for effective health management among the elderly [11, 12], and PA guidelines for older adults are suggested throughout the world [13]. The guidelines recommend that most elderly participate in at least 150 min of moderate activity, 75 min of vigorous activity, or an equivalent combination of both per week [14]. More than twice a week [4] or more than 30 min of long-term daily regular PA is reported to have a positive effect on physical function [14]. Weekly PA is highly related to physical function in old age, and it is known to contribute to independent activity and the promotion of quality of life in the elderly [15].

However, most previous studies that established the advantages of PA in the elderly used PA questionnaires [16, 17]. Stronger associations with cardiometabolic biomarkers have been reported using accelerometers as compared to self-reported PA questionnaires [18]. The use of various measuring sensors such as accelerometers enables more objective measurement of PA compared to questionnaires that depend on the participants' memory. The results using accelerometers that measure activity patterns in detail show higher reliability [19, 20]. Current guidelines provide minimum PA recommendations, but the advantages may differ by PA levels [21]. Recently, the use of wearable devices is increasing, and the concept of daily moderate-vigorous physical activity (MVPA) time has become increasingly popular. Therefore, the effectiveness of different PA levels should be tested and compared using various methods. Thus, this study aimed to compare the physical function and MetS factors according to levels of PA among elderly Korean men.

2. Methods

2.1 Participants

This study design is a cross-sectional pilot study. A total of 77 elderly men who visited two community welfare centers in Seoul, Republic of Korea, were enrolled. All participants in this study voluntarily participated and provided written informed consent. We had the following inclusion criteria for the study participants: aged over 65 years, ambulatory, completed the obesity and fitness test, and had available blood analysis results. The mean age was 74.21 $\pm$ 6.26 years.

2.2 Measurements

2.2.1 Physical activity

An accelerometer (Actical; Mini-Mitter Inc., Bend, OR, USA) was used to objectively measure light, moderate, and vigorous PA time. It has been tested for validity and reliability in previous studies [20, 22, 23]. The accelerometer was worn on the iliac crest using a belt to measure PA for 7 days. PA was automatically measured and stored by an internal sensor, and total energy expenditure (TEE, kcal/h) and activity energy expenditure were calculated based on the individual's age, sex, height, and weight. PA was classified into sedentary behavior (1.0-1.5 metabolic equivalents [METs]), light (1.5-3.0 METs), moderate (3.0-6.0 METs), and vigorous (over 6.0 METs) PA based on intensity [20]. The calculated value was expressed as the daily activity level and daily activity time (min/day). According to the Japanese Ministry of Health recommendations, participants were divided into a low, moderate, and high PA group based on their daily MVPA of less than 60, 60-120, and more than 120 min, respectively [24].

2.2.2 Body composition

Body composition and circumference were measured to determine the obesity rate. Body fat (%), fat mass (kg), and muscle mass (kg) were measured using InBody 720 (BioSpace, Seoul, Korea). The circumference of the waist, hip, and thigh was measured. Waist circumference was measured 1 cm above the navel, hip circumference was measured above the widest area of the hip, and thigh circumference was measured directly below the gluteal fold of the thigh (all in cm).

2.2.3 Physical function

Cardiorespiratory fitness was measured with the 6-min walk test (6MWT) [25]. The total distance walked by the participant for 6 min was measured and recorded as previously described [26].

Grip strength and leg extension were recorded as measurements of muscle strength. Mean grip strength (0.1 kg) was calculated from a total of four measurements (twice with the left hand and twice with the right hand) with a digital dynamometer (T.K.K.5401, TAKEI Scientific Instruments Co., Ltd., Niigata, Japan). Leg extension was measured with the participant seated on the dynamometer with both feet fitted under the padded arms and instructed to extend both legs with as much force as possible on command (T.K.K. 5710, TAKEI Scientific Instruments Co., Ltd., Niigata, Japan). The maximum extension value was recorded after two repetitions (0.1 kg).

The 10-m walk test was conducted to assess walking ability [27]. The time for walking a 10-m distance excluding the 1.5 m at the start and end was measured in duplicate. The better recorded time from the two measurements was used (0.1 s).

The SAHARA (DongJin Medical Co., Ltd., Seoul, Korea) was used for bone mineral density (BMD) measurements using ultrasonic waves to measure BMD in the calcaneus. The T-score and BMD were measured.

TABLE 1. Characteristics of male study participants for different physical activity levels (n = 77).

	Low PA (n = 17)	Middle PA (n = 38)	High PA (n = 22)	P
Age (years)	74.06 ± 5.96	74.84 ± 6.24	72.77 ± 6.57	0.448
Height (cm)	163.27 ± 5.15	164.92 ± 5.70	166.99 ± 5.69	0.119
Weight (kg)	61.08 ± 8.30	66.82 ± 7.73^a	66.59 ± 6.40	0.028*
Body mass index (kg/m^2)	24.49 ± 3.74	24.34 ± 3.28	23.05 ± 2.39	0.249
Comorbidity (yes, %)	12 (70.6)	22 (57.9)	10 (45.5)	0.065
Metabolic syndrome, n (%)	6 (31.58)	12 (63.16)	1 (5.26)	0.033*

Data are expressed as means ± standard deviations or n (%). PA: physical activity. $^aP <$ 0.05; significantly different from the low PA group. $^*P < 0.05$; tested by one-way analysis of covariance adjusted for age using the Scheffe (post hoc) test.

2.2.4 MetS-related risk factors

Oscillometry was used to measure blood pressure, with the cuff applied 2 cm above the cubital crease. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mmHg) were measured at 9 a.m. after 30 min of rest. Blood was also collected after these 30 min of rest and fasting for 8 h. High-density lipoprotein cholesterol (HDL-C), triglycerides (TG), and blood glucose were measured in the serum. The diagnostic standard for assessing MetS followed the National Cholesterol Education Program Adult Treatment Panel III criteria [28]. The criteria require that more than three of the following conditions are met: TG $\geq$ 150 mg/dL, HDL-C $<$ 50 mg/dL, fasting blood glucose (FBG) $\geq$ 100 mg/dL, SBP $\geq$ 130 mmHg, DBP $\geq$ 85 mmHg, or waist circumference $>$ 90 cm in men [28].

2.3 Statistical analysis

Data were analyzed using STATA version 15.0 (STATA Corp LLC., College Station, TX, USA). The mean and standard deviation were calculated for all categories. We performed normality tests using the Kolmogorov-Smirnov test. We selected parametric statistical methods based on normality tests, and one-way analysis of covariance was performed and adjusted for age based on the Scheffe (post hoc) test. Logistic regression analysis was conducted to obtain MetS odds ratios (ORs) for the different PA groups after adjusting for age. Statistical significance was defined as a P value < 0.05.

3. Results

There was no difference in age, height, body mass index (BMI), and comorbidity between the three PA groups (Table 1). Weight was significantly higher in the middle PA group than in the low PA group. There was a significant difference in the sedentary behavior time, light PA, moderate PA, vigorous PA, and total energy expenditure between the groups.

There were no significant differences in the waist, hip, and thigh circumferences between the three groups (Table 2). The high PA group showed a significantly lower percentage of body fat and fat mass and higher muscle mass than did the low and middle PA groups. The 6MWT was significantly longer and the T-score was higher in the high PA group than in the low and middle PA groups. All further results are shown in Table 2.

High-density lipoprotein cholesterol was significantly higher in the high PA group, and SBP was significantly higher in the middle group than in the low PA group (Table 3). There were no significant differences in the waist circumference, TG, FBG, and DBP between the groups.

As a result of the comparison of the participant ratio meeting more than three MetS criteria between the PA groups, the high PA group had an OR of 0.09 (95% confidence interval 0.01-0.82) compared with the low PA group ($P < 0.05$). No significant differences were observed for the BMI and comorbidity ($P > 0.05$) (Table 4).

4. Discussion

This study compared physical function and MetS factors according to the level of PA. As a result, physical function including CRF, strength, gait ability, and BMD was better among those performing more than 120 min of daily MVPA than among those with less than 60 min of daily MVPA. HDL-C and SBP as MetS-related factors showed significantly better values along with a lower OR of MetS.

In this study, the MetS factor according to PA level and difference of body composition including percent body fat and muscle mass was identified; this was consistent with findings of previous studies [29, 30]. The increase of PA is reported to reduce fat mass and obesity in the elderly. PA is linked to energy expenditure [14]. In a study that used a questionnaire, PA was reported to help prevent long-term loss of function by increasing lean body mass and decreasing fat mass [29]. Also, standard behavioral treatment (approximately 30 min of brisk walking per day) was the main factor for weight loss. Another group showed greater long-term effects by high levels of exercise (approximately 75 min of brisk walking per day), even though weight loss was similar [31]. Based on these results, we believe that the standard recommendation for exercise levels should be higher for a more positive effect on weight loss and obesity.

Our findings on the differences in physical function with the PA level comply with the results of other PA studies that used questionnaires and accelerometers [32, 33]. One study compared the physical function and gait ability based on a

TABLE 2. Body composition and metabolic syndrome risk factors for different physical activity levels (n = 77).

	Low PA (n = 17)	Middle PA (n = 38)	High PA (n = 22)	P
MetS risk factors				
Waist circumference (cm)	90.12 ± 8.14	86.18 ± 8.49	84.04 ± 5.93	0.087
HDL-C (mg/dL)	43.75 ± 7.77	52.16 ± 14.71	59.36 ± 14.16^{a}	0.003**
TG (mg/dL)	177.06 ± 112.79	134.66 ± 57.99	124.64 ± 55.15	0.073
FBG (mg/dL)	99.75 ± 21.29	94.58 ± 15.17	98.32 ± 36.03	0.725
SBP (mmHg)	141.78 ± 6.48	125.82 ± 15.71^{a}	130.00 ± 15.27	0.012*
DBP (mmHg)	81.07 ± 10.22	77.00 ± 8.94	77.53 ± 7.72	0.362
Body composition				
Body fat (%)	30.61 ± 6.79	30.12 ± 7.44	$24.77 \pm 6.00^{a,b}$	0.009**
Fat weight (kg)	18.48 ± 5.09	17.96 ± 5.43	$14.16 \pm 3.66^{a,b}$	0.008**
Muscle mass (kg)	43.85 ± 4.33	47.13 ± 6.02	48.56 ± 4.26^{a}	0.021*
Bone mineral density (g/cm^2)	23.32 ± 6.06	22.54 ± 6.50	27.81 ± 6.39^{a}	0.014*
BMD T-score	39.85 ± 21.17	41.00 ± 18.37	$50.84 \pm 15.73^{a,b}$	< 0.001***

PA: physical activity; HDL-C: high-density lipoprotein-cholesterol; TG: triglycerides; FBG: fasting blood glucose; SBP: systolic blood pressure; DBP: diastolic blood pressure; BMD: bone mineral density.
$^{a}P < 0.05$; significantly different from the low PA group.
$^{b}P < 0.05$; significantly different from the moderate PA group.
$*P < 0.05$, $**P < 0.01$, $***P < 0.001$; tested by one-way analysis of covariance adjusted for age using the Scheffe (post hoc) test.

TABLE 3. PA type and physical function by physical activity group (n = 77).

	Low PA (n = 17)	Middle PA (n = 38)	High PA (n = 22)	P
PA type				
Sedentary time (min/day)	1276.8 ± 77.18	1166.65 ± 86.67^{a}	$1088.62 \pm 88.55^{a,b}$	< 0.001***
Light exercise (min/day)	129.02 ± 76.07	194.37 ± 74.64^{a}	197.41 ± 61.53^{a}	0.005**
Moderate exercise (min/day)	39.96 ± 12.94	87.79 ± 17.37^{a}	$164.85 \pm 31.30^{a,b}$	< 0.001***
Vigorous exercise (min/day)	0.00 ± 0.00	0.10 ± 0.19	$0.65 \pm 1.47^{a,b}$	0.016*
TEE (kcal/day)	1185.29 ± 28.76	2274.64 ± 682.55^{a}	$3695.44 \pm 843.51^{a,b}$	< 0.001***
Physical function				
6-min walk test (m)	470.73 ± 66.57	487.66 ± 72.11	546.86 ± 46.94^{ab}	< 0.001***
Grip strength (kg)	23.32 ± 6.06	22.54 ± 6.50	27.81 ± 6.39^{b}	0.010*
Berg balance score (points)	44.07 ± 8.17	47.83 ± 7.89	51.45 ± 6.23^{a}	0.022*

PA: physical activity; TEE: total energy expenditure.
$^{a}P < 0.05$; significantly different from the low PA group.
$^{b}P < 0.05$; significantly different from the moderate PA group.
$*P < 0.05$, $**P < 0.01$, $***P < 0.001$; tested by one-way analysis of covariance adjusted for age using the Scheffe (post hoc) test.

TABLE 4. Association between obesity-related factors and physical activity in elderly males (n = 77).

Groups Variables	Low PA (n = 17)	Middle PA (n = 38)	High PA (n = 22)
Body mass index (kg/m^2)	1.00 (Reference)	1.19 (0.36–3.92)	0.41 (0.09–1.77)
Body fat (%)	1.00 (Reference)	1.02 (0.29–3.59)	0.42 (0.11–1.58)
Metabolic syndrome ($\geq$ 3 items)	1.00 (Reference)	0.85 (0.25–2.83)	0.09 (0.01–0.82)*

OR: odds ratio; CI: confidence interval.
$*P < 0.05$; tested by logistic regression analysis adjusting for age.
Body mass index: ≥ 25 kg/m^2, body fat: $\geq 25\%$.
Metabolic syndrome: waist circumference ≥ 90 cm, triglycerides ≥ 150 mg/dL, high-density lipoprotein-cholesterol < 40 mg/dL, blood pressure $\leq 130/\leq 85$ mmHg, fasting blood glucose ≥ 100 mg/dL.

PA questionnaire in 26 elderly men and women and reported a positive relationship between PA, CRF, and gait ability [34]. Another study used an accelerometer to measure PA among elderly participants and reported a positive correlation between MVPA, gait speed, and balance with a 1.4-2.7% higher level per 10-min increase in MVPA [35]. A different accelerometer study among elderly women reported better fitness (chair stands, up and go test, and 6 min step test) for those who met the recommendation of more than 150 min of MVPA per week than those who did not [24]. Accelerometer measurements also confirmed higher cardiorespiratory function among elderly men performing more than 60 min of daily MVPA than among those who performed less (n = 22) [36]. Moreover, in our study, participants performing more than 120 min of MVPA daily showed significantly higher CRF, strength, gait ability, and BMD than those who did less than 120 min of MVPA. Therefore, more than 120 min PA is required to maintain and improve physical function in people over 65 years of age.

We also found significantly lower OR of MetS in participants who performed more than 120 min of daily MVPA than in those who did less. In general, regular PA is known to be effective for weight loss, lowering blood pressure, and improving blood lipids levels, including HDL-C and TG [37]. A PA study that used an accelerometer in male and female participants with a mean age of 47.5 years reported that for each additional 1000 steps per day, MetS incidence was reduced by 10% [38]. A study among adults (mean age 53.4 years) using an accelerometer also reported that longer or more MVPA was related to lower TG, sedentary behavior time, and light PA time. They observed a 3.1-cm increase of waist circumference by every 10% increase of sedentary behavior time [39]. A study by Nilsson *et al.* [40] with elderly women suggested the use of MVPA for health promotion in the elderly, as high MVPA has a greater significant impact on MetS health-related factors.

It is reported that high levels of PA and CRF have a positive impact on MetS as it is related to obesity, blood glucose, and cardiovascular function [41, 42]. Some studies reported that CRF (as reflected by VO_{2max}) is an objective health index that shows a close relationship with the risk of MetS [43]. Our study also showed higher CRF levels, strength, and gait ability in those performing more than 120 min of daily MVPA; these results confirmed the lower MetS risk found in other studies. However, the existing literature found positive effects for PA of more than 60 min daily and 150 min weekly [44]. Public health recommendations have specified different levels of activity for these two groups-30 to 60 min of PA for individuals who need to avoid weight gain and 60 to 90 min of PA for individuals needing to avoid regaining weight [45]. MetS risk in our study was only meaningfully lowered in those performing more than 120 min MVPA per day. Simply, this study used an accelerometer, which resulted in higher PA levels than did other studies as it included all daily activities including exercise.

There are limitations to this study. Our participants are not representative of the whole Korean population as it was conducted only in Seoul. Also, unlike a general cohort study, our cross-sectional design does not allow us to determine MetS prevalence. However, our study has higher reliability and validity than questionnaire-based studies because we used an accelerometer to measure PA directly and the number of participants is greater than most studies in the literature. Future studies should investigate the influence of PA patterns on physical function maintenance and MetS prevalence in the elderly in the long term.

5. Conclusions

Elderly men who performed more than 120 min of MVPA daily showed better physical function measured as CRF, strength, gait ability, and BMD and had a lower incidence of MetS than those who performed less MVPA daily.

Acknowledgements

Thank numerous individuals participated in this study.

Conflict of interest

The authors declare no conflicts of interest.

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