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Research article

Differences in physical fitness and cardiovascular function depend on BMI in Korean men

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Abstract
We investigated the associations between cardiovascular function and both body mass index and physical fitness in Korean men. The subjects were 2,013 men, aged 20 to 83 years, who visited a health promotion center for a comprehensive medical and fitness test during 2006-2009. The WHO's Asia-Pacific Standard Report definition of BMI was used in this study. Fitness assessment of cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, power, agility, and balance were evaluated by VO_2max (ml/kg/min), grip strength (kg), sit-ups (reps/min), sit and reach (cm), vertical jump (cm), side steps (reps/30s), and standing on one leg with eyes closed (sec), respectively. For cardiovascular function, we evaluated systolic blood pressure (SBP), diastolic blood pressure (DBP), resting heart rate (RHR), double product (DP), and vital capacity. There were significant decreases in cardiorespiratory endurance ($p < 0.001$), power ($p < 0.001$), and balance ($p < 0.001$), and increases in muscular strength ($p < 0.001$). Further, cardiovascular function, including SBP ($p < 0.001$), DBP ($p < 0.001$), double product ($p < 0.001$), and vital capacity ($p=0.006$) appeared to be lower for the obesity group. We conclude that an obese person exhibits lower fitness level and weaker cardiovascular function than a normal person.

Key words: Body mass index, obesity, physical fitness, cardiovascular function.

Introduction

Obesity is a serious social issue worldwide. In 2005, the World Health Organization announced that approximately 1.6 billion adults are overweight by the age of fifteen, and of this population, at least 400 million adults are obese. The World Health Organization predicted that the number of overweight adults and obese adults will be approximately 2.3 billion and 700 million, respectively, by the end of 2015 (World Health Organization, 2010).

Obesity is a major risk factor of cardiac disease, cancer, diabetes, and mortality. Also, obesity can aggravate chronic diseases, such as hypertension, arthritis, cholelithiasis, and hypercholesterolemia. For these reasons, numerous efforts are necessary to prevent obesity (Wadden and Stunkard, 2002).

In general, obese adults have lower fitness levels compared to the normal population (Wei et al., 1999). In addition to risk factors that prevent physical activity, a lower level of physical fitness is an independent risk factor, which increases the risk of developing chronic diseases (e.g., cardiovascular diseases) and raises mortality rates due to all etiological factors (Adamu et al., 2006). Accordingly, in addition to decreasing physical fitness level, the risk of causing prevalence and mortality due to chronic diseases increases in obese adults.

Principles of physical education subdivide fitness into health-related physical fitness and motor-related physical fitness. Health-related physical fitness consists of cardiorespiratory endurance, muscular strength, muscular endurance, and flexibility. Motor-related physical fitness consists of power, agility, and balance (Vivian, 2006). Although there are numerous, detailed fitness categories, current researchers predominantly choose cardiorespiratory endurance when assessing fitness level (Blair et al., 2001).

Cardiorespiratory endurance (VO_2max) is indubitably a gold standard for assessing physical fitness; however, supplementary research is needed to characterize the relationship between various physical fitness measures and obesity for establishing principles physical education.

Therefore, this study sought to confirm the relationships between physical fitness variables and obesity in grown men according to age group and to emphasize the importance of physical fitness level for preventing obesity. In addition, we explored measures of cardiovascular function, which can be used to evaluate physical performance indirectly.

Methods

Subjects

Subjects were 2013 Korean male adults over the age of 20. Subjects visited a health promotion center at Yang-Cheon Gu, Seoul and took a comprehensive medical and fitness test between 01-01-2006 and 12-31-2009. Subjects who consumed drugs or had a history of stroke, cancer, heart failure, angina, or myocardial infarction were excluded from the study.

Experimental procedures

Subjects' height and weight was measured, and body mass index (BMI) was calculated from these results. The study used the WHO's Asia-Pacific standard of obesity: $BMI<23$ = normal, $23 \leq BMI<25$ = overweight, $BMI \geq 25$ = obese (WHO/IASO/IOTF, 2000).

Fitness assessment of cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, power, agility, and balance were evaluated by VO_2max

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($ml \cdot kg^{-1} \cdot min^{-1}$), grip strength (kg), sit-ups (reps/min), sit and reach (cm), vertical jump (cm), side steps (reps/30s), and standing on one leg with eyes closed (sec), respectively.

The maximal oxygen consumption (VO_2max) was obtained from YMCA submaximal test using a cycle erogometer (Helmas SH-9600K, Korea). Through gradual increase of the exercise intensity which was started 150kgm for 3min and increased via YMCA protocol, the maximal oxygen consumption (VO_2max) was estimated (Golding, 2000). Also, the heart rate of each subject was monitored using Polar HR monitor system (Polar S610, Finland).

Grip strength was evaluated by recording the average (of three measurements) full-strength power (kg) generated by subjects using a grip strength dynamometer (Helmas SH-9600D, Korea), which was adjusted to the second knuckle of their fingers.

The number of sit-ups performed in a 60 second period was recorded for subjects lying on a sit-up board (Helmas SH-9600N, Korea), using their upper body only with their knees bent at right angles and both hands held behind their necks.

For the sit and reach test, subjects sat on a flexibility measuring instrument (Helmas SH-9600G, Korea) with their heels positioned at the edge and their knees pointed upwards, and they bent forward at the waist with their hands outstretched to push the measuring instrument; the test was administered three times, and the average value was recorded.

Subjects performed a vertical jump three times on a vertical jump board (Hermas SH-9600F, Korea), and we recorded the average value in cm.

The side step was measured as follows. Subjects stood on a board (Helmas SH-9600J, Korea) with a midline (white) in the center of the board. On either side of the midline was a parallel line (white) 100 cm from the midline. Initially, subjects stood with both feet on the midline. They stepped rightwards until their right foot crossed the right line. Next, they stepped leftwards until their leftfoot crossed over the midline, and they returned to the original posture on the midline. Next, they stepped leftwards until their left foot crossed the left line. To complete the maneuver, they returned to the midline. They repeated this maneuver for 30 s, and the total frequency of repeated maneuvers was determined.

To assess the ability to stand on one leg with eyes closed, subjects closed their eyes and stood on one leg on a balance measuring instrument (Helmas SH-9600H, Korea); we administered the test three times and calculated the average time (s) until the second foot touched the ground.

For cardiovascular function, we evaluated systolic blood pressure (SBP), diastolic blood pressure (DBP), resting heart rate (RHR), double product (DP), and vital capacity.

After subjects rested comfortably for at least 10 minutes, a nurse practitioner measured SBP and DBP using a sphygmomanometer (Alpk, Japan) at the right brachial artery. These values were measured three times, and the average values were determined. Resting heart rate was determined by attaching a heart rate sensor (Polar S610, Finland) to a subject's chest for one minute. DP was determined by SBP X HR. A vital capacity measuring instrument (Helmas SH-9600C, Korea) was attached to subject's mouth, and the maximum exhalation value was determined after a deep breath.

Statistical analysis

All results from this study are shown as the average and standard deviation. To determine the difference in fitness and cardiovascular function between BMI groups (normal group, overweight group, and obese group), we used one-way ANOVA and administered a post-hoc test to determine noted differences related to groups. All analyses were performed using SPSS version 12.0 software (SPSS, Chicago, IL, USA). Statistical significance levels were calculated: $p < 0.05$, $p < 0.01$ and $p < 0.001$.

Results

Subject characteristics

Subject characteristics are shown in Table 1. The average age of the subjects was 47.3 ± 14.3 years, ranging from 20 to 83 years; the average height was 1.69 ± 0.06 m, ranging from 1.48 to 1.91 m; the average weight was 69.6 ± 9.3 kg, ranging from 40.0 to 116.0 kg; and the average BMI was 24.43 ± 2.82 $kg \cdot m^{-2}$ (16.46- 34.45). According to their BMIs, 623 subjects (30.9%) were of normal weight, 578 (28.7%) were overweight, and 812 (40.3%) were obese.

Table 1. General characteristics of the study population (n = 2 013). Data are means ± (SD).

Group	Normal	Overweight	Obese
Age (year)	46.7 (16.2)	48.2 (14.4)	47.2 (12.4)
Height (m)	1.69 (.06)	1.69 (.06)	1.68 (.06)
Weight (kg)	60.8 (5.9)	68.9 (5.4)	76.8 (7.6)
BMI ($kg \cdot m^{-2}$)	21.27 (1.37)	24.05 (.57)	27.13 (1.76)
20s (n)	120	78	63
30s (n)	116	87	177
40s (n)	114	128	204
50s (n)	99	136	221
60s (n)	123	122	128
Over 70 (n)	51	27	19
Total number (%)	623 (30.9%)	578 (28.7%)	812 (40.3%)

BMI, Body mass index

The relationship between BMI and health-related physical fitness

The relationship between BMI and health-related physical fitness is shown in Table 2. The VO_2max level decreased significantly in the obese group, except for those over 70 ($p < 0.01$). When calculated over the entire age range, VO_2max levels decreased in the obese group ($p < 0.001$). The muscular strength level increased significantly in the obese group, except for subjects in their 20s or 60s or for those over 70 ($p < 0.05$). Also, muscular strength increased in the obese group (calculated over the entire age range) ($p < 0.001$). The muscular endurance level increased in the obese group for subjects in their 30s and 40s ($p < 0.05$). However, averaged over all age

Table 2. Analysis of health-related physical fitness. Data are means (±SD).

Group Age	Variable	Normal	Overweight	Obese	Overall F	Overall p
20s	Cardiorespiratory endurance (ml·kg^{-1}·min^{-1})	37.26 (6.32)	33.08 (5.53) ###	31.37 (6.21) ###	21.125	<.001***
30s		36.17 (5.32)	34.67 (4.80)	32.37 (5.20) ###	18.917	<.001***
40s		35.17 (5.25)	32.65 (5.60) ##	32.06 (5.42) ###	11.507	<.001***
50s		34.20 (5.23)	31.79 (4.95 ##	31.05 (4.65) ###	12.434	<.001***
60s		32.83 (4.94)	31.16 (5.81)	29.87 (4.94) ##	7.137	.001**
Over 70		33.61 (7.27)	31.93 (6.86)	31.37 (7.61)	.484	.619
Total		35.21 (5.76)	32.56 (5.48) ###	31.50 (5.25) ###	71.425	<.001***
20s	Muscular strength (kg)	37.76 (4.55)	39.09 (6.30)	39.34 (7.77)	1.877	.155
30s		39.04 (4.18)	41.51 (4.99) ##	41.26 (5.26) ##	8.896	<.001***
40s		38.69 (4.40)	38.67 (4.82)	40.30 (5.25) #	5.802	.003**
50s		37.20 (4.22)	37.89 (3.89)	38.77 (4.88) #	4.406	.013*
60s		35.21 (4.23)	36.16 (5.29)	36.57 (4.57)	2.572	.078
Over 70		33.59 (3.97)	34.44 (4.41)	34.69 (5.64)	.538	.586
Total		37.26 (4.60)	38.25 (5.27) ##	39.32 (5.55) ###	26.888	<.001***
20s	Muscular endurance (reps/min)	25.13 (5.98)	24.57 (6.41)	23.43 (7.58)	1.342	.263
30s		21.79 (4.67)	23.60 (5.60) #	22.36 (4.47)	3.485	.035*
40s		18.93 (4.77)	19.63 (4.24)	21.18 (4.63) ###	9.195	<.001***
50s		16.84 (4.46)	17.61 (5.75)	17.26 (4.42)	.674	.510
60s		15.18 (5.16)	14.75 (4.11)	15.78 (6.66)	.991	.373
Over 70		14.02 (4.45)	16.26 (4.46)	15.79 (3.44)	.788	.459
Total		19.38 (6.26)	19.35 (6.20)	19.68 (6.08)	.572	.565
20s	Flexibility (cm)	11.38 (10.00)	13.26 (12.58)	12.31 (9.97)	.698	.499
30s		12.21 (8.83)	14.20 (7.66)	11.65 (9.13)	2.448	.088
40s		10.88 (8.53)	11.30 (8.57)	10.48 (8.03)	.366	.694
50s		10.04 (10.98)	9.68 (9.46)	8.22 (9.22)	1.517	.220
60s		8.67 (9.80)	8.61 (9.94)	6.77 (10.81)	1.315	.270
Over 70		8.87 (8.34)	8.68 (11.10)	3.52 (11.41)	2.024	.138
Total		10.51 (9.58)	10.94 (9.87)	9.54 (9.49)	3.730	.024*

* p < 0.05 ** p < 0.01 *** p < 0.001 by one-way ANOVA
# p < 0.05 ## p < 0.01 ### p < 0.001; compared to normal group (tukey post-hoc)

groups, muscle endurance levels did not show statistical increases in muscular endurance of the obese group ($p > 0.05$). The flexibility level did not vary between age groups, but averaging across age groups showed that the flexibility of the obese group decreased ($p < 0.05$). However, the post-hoc test did not show any statistical difference in flexibility level between the groups ($p > 0.05$).

The relationship between BMI and motor-related physical fitness

The relationship between BMI and motor-related physical fitness is shown in Table 3. The power level decreased as BMI increased for all ages except for subjects in their 40s and 60s ($p < 0.05$). Also the power level decreased significantly in the obese group when averaged over all ages ($p < 0.001$). Agility level did not demonstrate a difference as BMI increased except for subjects in their over 70 ($p > 0.05$). Averaging over all age groups, there was no difference in agility level ($p > 0.05$). The balance level decreased as BMI increased for subjects in their 20s and 30s ($p < 0.01$), and the balance score of the total group decreased significantly with an increase in BMI ($p < 0.001$).

The relationship between BMI and cardiovascular function

The relationship between BMI and cardiovascular function is shown in Table 4. The SBP and DBP increased with increasing BMI for all age groups ($p < 0.01$). And averaging over all age groups showed that SBP and DBP increased significantly with BMI ($p < 0.001$). The RHR did not show a statistical difference for the obese group except for subjects in their 20s ($p > 0.05$). There was no difference when values were averaged across all age groups ($p > 0.05$). The DP increased with increasing BMI for all age groups except for subjects in their 40s ($p < 0.05$). Averaged over all ages, DP increased significantly with BMI ($p < 0.001$). Overall p-value shows that vital capacity in the obese group decreased for all ages except for subjects in their 30s and 60s ($p < 0.05$). All age groups, vital capacity decreased significantly as BMI increased ($p < 0.01$).

Discussion

As a person becomes more obese, the body becomes less sensitive, further limiting the scope of everyday activities. This physical inactivity in turn leads to the habit of remaining seated while working. Thus, it is natural to

Table 3. **Analysis of motor-related physical fitness. Data are means (±SD).**

Group Age	Variable	Normal	Overweight	Obese	Overall F	Overall p
20s	Power (cm)	58.13 (14.14)	55.35 (15.22)	50.39 (16.11) ##	5.096	.007**
30s		53.49 (9.68)	55.10 (9.07)	51.02 (9.82) #	5.535	.004**
40s		46.39 (9.48)	45.57 (10.05)	44.79 (9.94)	.881	.415
50s		40.10 (9.05)	38.06 (8.15)	36.48 (8.63) ##	5.546	.004**
60s		30.99 (8.45)	29.83 (7.97)	28.91 (8.34)	1.669	.190
Over 70		29.17 (8.12)	27.95 (10.82)	22.14 (8.26) #	3.236	.045*
Total		45.09 (14.62)	42.97 (14.00) #	41.59 (12.89) ###	10.193	<.001***
20s	Agility (reps/30s)	35.71 (7.99)	35.06 (6.53)	33.10 (8.76)	2.184	.115
30s		39.63 (6.06)	40.45 (5.68)	39.44 (5.69)	.869	.420
40s		35.77 (5.40)	35.49 (5.04)	35.08 (5.81)	.551	.577
50s		32.08 (7.22)	31.75 (5.91)	31.40 (4.92)	.409	.665
60s		27.59 (5.52)	27.21 (5.63)	27.33 (5.14)	.121	.886
Over 70		28.31 (7.25)	25.65 (6.37)	21.31 (5.44) ##	5.443	.006**
Total		33.98 (7.79)	33.39 (7.26)	33.63 (7.14)	.872	.418
20s	Balance (sec)	89.74 (51.61)	82.90 (54.75)	62.22 (42.92) ##	5.433	.005**
30s		75.90 (37.94)	78.09 (34.72)	59.40 (36.82) ##	10.288	<.001***
40s		52.75 (40.67)	49.38 (36.04)	43.20 (32.46)	2.740	.066
50s		41.50 (34.17)	33.40 (30.20)	35.61 (31.88)	1.830	.162
60s		22.73 (24.41)	19.85 (21.71)	19.11 (22.61)	.793	.454
Over 70		29.39 (39.47)	12.71 (9.23)	14.81 (12.52)	3.018	.054
Total		54.56 (45.74)	46.48 (41.84) ##	41.84 (35.58) ###	16.121	<.001***

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ by one-way ANOVA
\# $p < 0.05$ ## $p < 0.01$ ### $p < 0.001$; compared to normal group (tukey post-hoc)

expect that an obese person would have a lower fitness level. However, most of the existing studies restricted the key evaluation parameters of fitness level to VO_2max, which is an indicator of cardio-respiratory endurance (Meyers et al., 1991; Wei et al., 1999). Due to this limitation of previous studies, the current study evaluated other fitness parameters, in addition to VO_2max, to analyze the fitness level differences between obese and average subjects.

Among health-related physical fitness parameters, cardio-respiratory endurance was low for the obese group at almost every age, which agrees with results from previous studies (Meyers et al., 1991; Wei et al., 1999). This is likely related to the higher heart disease prevalence in obese populations. Obesity overloads the heart through increases of triglycerides and low-density lipoprotein (LDL) levels and decreases in high-density lipoprotein (HDL) levels. An overloaded heart disturbs heart function or induces heart failure (Bray, 1996). This can be interpreted as a decrease in cardio-respiratory endurance. Jette et al. (1990) demonstrated that as a person becomes increasingly obese, their cardio-respiratory endurance and muscular endurance decrease and their muscular strength rather increase. This suggests that a higher level of obesity affects everyday life, which leads to increased muscular strength. This study also supports the theory that people of higher obesity levels maintain higher levels of muscular strength. Although muscular endurance and flexibility of an obese person do not differ substantially from those of an average person, it was demonstrated that an obese person tends to exhibit lower cardio-respiratory endurance and higher muscular strength.

Of the motor-related physical fitness parameters, power and balance were shown to be lower for the obese group compared to the normal group. However, there was no statistically significant difference in agility. Since power is defined as force multiplied by speed (Vivian, 2006), we can infer that this phenomenon develops because increased weight adversely affects speed, consequently decreasing power. In addition, obesity decreases balance levels because an obese person has greater difficulty balancing his body on only one leg than a normal person. This result is further supported by the findings of Coakley et al. (1998), who tested elderly subjects. Consequently, it is demonstrated that the findings of this study are consistent with previous studies in other age groups.

Obesity stimulates the sympathetic nervous system as hyper-insulinemia develops and sodium accrues. This stimulated sympathetic nervous system increases the risk of hypertension (Mikhail et al., 1999). This implies that obesity plays a crucial role in both the initiation and development of hypertension. In line with this implication, this study also implies that obese people in every age group suffer from higher SBP and DBP than normal people. Although there was no significant difference in resting heart rate between the two groups, the burden to the myocardium (DP) appears lower for the obese group. This observation helped us to confirm the correlation between obesity and blood pressure. In addition, the obese group had a lower level of vital capacity, which implies weaker cardiovascular function.

Obesity stimulates the sympathetic nervous

Table 4. Analysis of cardiovascular function. Data are means (±SD).

Group Age	Variable	Normal	Overweight	Obese	Overall F	Overall p
20s	SBP (mmHg)	115.3 (12.4)	123.9 (11.7) ###	127.0 (14.5) ###	20.926	<.001***
30s		117.9 (12.7)	122.6 (16.3)	127.0 (14.7) ###	13.708	<.001***
40s		120.5 (15.6)	124.8 (15.4)	129.8 (15.6) ###	13.598	<.001***
50s		120.8 (17.2)	128.4 (18.5) ##	132.7 (17.6) ###	15.300	<.001***
60s		124.6 (18.4)	132.5 (19.0) ##	138.5 (16.8) ###	18.499	<.001***
Over 70		123.6 (16.0)	136.7 (19.1) ##	136.8 (19.5) #	6.679	.002**
Total		120.1 (15.7)	127.4 (17.3) ###	131.3 (16.6) ###	80.450	<.001***
20s	DBP (mmHg)	68.4 (8.0)	73.3 (8.9) ##	75.8 (9.9) ###	16.595	<.001***
30s		74.3 (8.1)	77.5 (10.0) #	79.5 (8.9) ###	12.043	<.001***
40s		77.0 (9.8)	79.3 (10.3)	82.8 (9.8) ###	13.315	<.001***
50s		76.7 (11.3)	81.0 (11.5) #	84.3 (10.8) ###	16.312	<.001***
60s		78.3 (11.5)	81.7 (11.3) #	84.1 (10.3) ###	8.827	<.001***
Over 70		73.5 (9.5)	83.8 (12.1) ###	83.8 (8.3) ##	12.459	<.001***
Total		74.8 (10.3)	79.3 (11.0) ###	82.2 (10.3) ###	87.761	<.001***
20s	RHR (beats/min)	73 (12)	73 (11)	78 (13) #	3.868	.022*
30s		72 (10)	71 (12)	73 (10)	1.177	.309
40s		72 (10)	70 (10)	71 (11)	1.084	.339
50s		73 (11)	74 (10)	72 (10)	1.415	.244
60s		73 (11)	70 (9)	71 (11)	2.326	.099
Over 70		69 (11)	74 (12)	75 (14)	2.767	.068
Total		73 (11)	72 (11)	72 (11)	.703	.495
20s	Double product (HR X SBP)	8427 (1707)	9065 (1898)	9978 (2449) ###	12.831	<.001***
30s		8540 (1730)	8737 (2067)	9331 (1895) ##	6.890	.001**
40s		8763 (2009)	8825 (1888)	9215 (1960)	2.558	.079
50s		8896 (2047)	9510 (2043)	9565 (1963) #	4.073	.018*
60s		9169 (2163)	9322 (1932)	9934 (2194) #	4.623	.010*
Over 70		8580 (2121)	10165 (2196)	10274 (2373)	6.625	.002**
Total		8743 (1963)	9172 (2004) ##	9532 (2051) ###	27.019	<.001***
20s	Vital capacity (L)	4.12 (.85)	4.50 (.98) #	4.31 (1.09)	3.521	.031*
30s		4.08 (.63)	4.01 (.71)	3.88 (.73)	2.932	.055
40s		3.85 (.72)	3.54 (.89) ##	3.67 (.80)	4.363	.013*
50s		3.56 (.74)	3.46 (.86)	3.25 (.82) ##	5.707	.004**
60s		3.21 (.80)	3.02 (.83)	3.00 (.73)	2.418	.091
Over 70		2.67 (.68)	3.21 (.88) #	2.68 (.72)	4.534	.014**
Total		3.69 (.87)	3.59 (.97)	3.53 (.90) ##	5.121	.006**

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ by one-way ANOVA
# $p < 0.05$ ## $p < 0.01$ ### $p < 0.001$: Compared to normal group (tukey post-hoc)
SBP, systolic blood pressure; DBP, diastolic blood pressure; RHR, resting heart rate.

system as hyper-insulinemia develops and sodium accrues. This stimulated sympathetic nervous system increases the risk of hypertension (Mikhail et al., 1999). This implies that obesity plays a crucial role in both the initiation and development of hypertension. In line with this implication, this study also implies that obese people in every age group suffer from higher SBP and DBP than normal people. Although there was no significant difference in resting heart rate between the two groups, the burden to the myocardium (DP) appears lower for the obese group. This observation helped us to confirm the correlation between obesity and blood pressure. In addition, the obese group had a lower level of vital capacity, which implies weaker cardiovascular function.

The limitation of this study is rooted in the use of cross-sectional methodology. The study therefore only clarifies the correlation between obesity and physical fitness; it does not demonstrate a causal relationship between the two. Also, the data are not representative of all Korean men since the participants only resided in Seoul. However, the large number of subjects (2,000) is a primary merit of this study compared to others. When extended to a cohort study, this study may provide a solid base for more in-depth research investigating the correlation between obesity, physical fitness, and cardiovascular function for Koreans and other Asians.

Conclusion

The obese group had a lower fitness level, including cardiorespiratory endurance, power, and balance, but the obese group demonstrated an increase in muscular strength. In addition, we found that the obese group had higher blood pressure and weaker cardiovascular function, including DP and vital capacity, than the normal group.

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Key points

- The obese group had a lower fitness level, including cardiorespiratory endurance, power, and balance.
- Obese group demonstrated an increase in muscular strength.
- Obese group had higher blood pressure and weaker cardiovascular function, including DP and vital capacity, than the normal group.

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