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Original Article

Associations of Hypertension Status with Physical Fitness Variables in Korean Women

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Abstract

Background: In Korea, hypertension has become more prevalent with the Westernization of Korean diets and lack of exercise. This study aimed at investigating the associations between physical fitness variables and hypertension status in Korean women.

Methods: The subjects were 9,216 women aged >20 years who visited a public health promotion center for physical fitness tests. Cardiovascular respiratory fitness was evaluated using VO_2max, resting heart rate (RHR), double product (DP), and vital capacity and coordination-related physical fitness was measured using grip strength, number of sit-ups completed, sit-and-reach score, vertical jump height, number of side steps performed, and 1-leg standing with eyes open.

Results: The prevalence rates of prehypertension and hypertension were 30.3% and 12.9% in this study, respectively. After adjusting for age, body mass index, drinking frequency, smoking intensity, and exercise intensity, the odds ratios (95% confidence interval) were calculated, and no statistically significant association was found between hypertension and physical fitness as measured by grip strength (P = 0.056), number of sit-ups completed (P = 0.140), and vertical jump height (P = 0.121). However, significant associations were found between hypertension and VO_2max (P < 0.001), RHR (P < 0.001), DP (P < 0.001), vital capacity (P < 0.001), sit-and-reach score (P = 0.012), the number of side steps performed (P = 0.001), and 1-leg standing with eyes open (P < 0.001).

Conclusion: We found that all the cardiovascular respiratory fitness variables and half of the motor- and coordination-related physical fitness variables were closely related with hypertension status.

Keywords: Hypertension, Cardiovascular respiratory fitness, Korea

Introduction

The number of hypertension cases in Korea has been recently increasing with the Westernization of Korean diets and lack of exercise. Data from the Korea Health Statistics 2011: Korea National Health and Nutrition Examination Survey (KNHANES V-2) indicated that the rate of prevalence of hypertension in women aged > 30 years was 27.8% (1).

Hypertension is a major risk factor for stroke and cardiovascular disease (CVD). It is caused by genetic and lifestyle-related factors (2-3), which usually promote stress and obesity. In addition, physical fitness, as assessed by maximal exercise testing (quantifying the ability of the body to transport and use oxygen, VO_2max), is considered as an important risk factor for hypertension and CVD (4-7) based on epidemiological evidence of its strong association with survival from hypertension due to CVD and non-CVD causes (4-9).

According to physical training principles, physical fitness is subdivided into 2 categories: cardiovascular respiratory fitness and motor- and coordination-related physical fitness. Cardiovascular respiratory fitness is measured by cardiorespiratory endurance (VO_2max), resting heart rate (RHR), double product (DP), and vital capacity and coordination-related physical fitness is measured by muscular strength, muscular endurance, flexibility, power, agility, and the ability to maintain balance (10). Among numerous detailed physical fitness categories, current researchers predominantly choose cardiorespiratory endurance (VO_2max) as a measure of physical fitness level (11).

VO_2max is indubitably a standard criterion for assessing physical fitness (10, 12). However, supplementary research is needed to characterize the association between other physical fitness variables and hypertension status, which is crucial in establishing clinical principles in physical training. Therefore, using multivariate logistic regression analyses, this study sought to confirm the associations between the other physical fitness variables and hypertension status in Korean women.

Materials and Methods

Subjects

The subjects of this cross-sectional study were 9,216 women aged ≥20 years who visited a public health promotion center in Seoul, South Korea, during 2006–2010 to undergo cardiovascular respiratory fitness and motor- and coordination-related physical fitness tests. The subjects provided written consent to participate in this study. All the study procedures were approved by the Human Care and Use Committee of the Y-gu Public Health Promotion Center. The characteristics of the subjects are shown in Table 1.

Experimental procedures

Covariate variables

The subjects were categorized according to self-reported data as follows: smoking habit (non-smoker, <1 pack of cigarettes per day, and ≥1 pack of cigarettes per day), drinking habit (non-drinker, 1 or 2 times per week, and ≥3 times per week), and exercise training (no exercise, 1 or 2 times per week, and ≥3 times per week).

Height and weight were measured using Inbody 720 (Biospace, Seoul, Korea), from which the body mass index value (BMI, kg/m^2) was derived. According to the World Health Organization Asia-Pacific standard of obesity, women with a BMI < 23, ≥23 but <25, or ≥25 kg/m^2 were described as normal, overweight, or obese, respectively (13).

Dependent variables

After filling out the questionnaires and resting for >10 minutes in a sitting position, systolic blood pressure (SBP) and diastolic blood pressure (DBP) at the right brachial artery were measured by a nurse practitioner using a mercury sphygmomanometer (ALPK, Japan). The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure VII defines hypertension, prehypertension, and normal tension as blood pressures > 140/90, 120–139/80–89, and <120/80 mm Hg, respectively (14). Blood pressure was measured 3 times at 2-minute intervals. The nurse specialist determined the mean blood pressure (15).

Independent variables

Cardiovascular respiratory fitness was evaluated by measuring cardiorespiratory endurance, RHR, DP, and vital capacity. Cardiorespiratory endurance (VO_2max, mL/kg/min) was determined using the YMCA submaximal test, using a cycle ergometer (Helmas-SH-9600K; South Korea). VO_2max was estimated by gradually increasing the exercise intensity, starting from 150 kgm for 3 minutes via the YMCA protocol (16). The heart rate and RHR of each subject were monitored using the Polar HR monitor system (Polar-S610; Finland). DP was calculated as SBP × HR. To measure vital capacity, the pneumatic sensor of the measuring instrument (Helmas-SH-9600C; South Korea) was attached to the mouth. The maximum exhalation volume (liters) was measured after deep inhalation.

Table 1: The characteristics of the subjects (n = 9,216)

Variables			**Mean ± standard deviation or n (%)**
Age (yr)			46.83 ± 10.32
Anthropometry	Height (cm)		156.79 ± 5.23
	Weight (kg)		57.94 ± 7.60
	Body mass index (kg/m²)		23.58 ± 2.92
SBP (mm Hg)			118.70 ± 17.05
DBP (mm Hg)			73.22 ± 10.62
Cardiovascular respiratory fitness	VO_2max (ml/kg/min)		26.39 ± 5.17
	RHR (beats/min)		74.08 ± 9.50
	Double product (HR × SBP)		8,816.15 ± 1,841.42
	Vital capacity (ℓ)		2.75 ± 0.58
Motor- and Coordination-related physical fitness	Grip strength (kg)		28.32 ± 3.77
	Sit-ups (repetitions/min)		12.87 ± 5.97
	Sit-and-reach (cm)		17.38 ± 7.99
	Vertical jump height (cm)		24.42 ± 7.44
	Side steps (repetitions/30 s)		30.62 ± 5.60
	1-leg standing with eyes open (s)		42.31 ± 37.64
Body mass index (kg/m²)	Normal	<23	4237 (46.0%)
	Overweight	≥23 to <25	2397 (26.0%)
	Obese	≥25	2582 (28.0%)
Smoking	Nonsmoker		9,013 (97.8%)
	<1 pack of cigarettes per day		164 (1.8%)
	≥1 pack of cigarettes per day		39 (0.4%)
Drinking	Nondrinker		7,918 (85.9%)
	1 or 2 times per week		1,078 (11.7%)
	≥3 times per week		220 (2.4%)
Exercise	No exercise		4,432 (48.1%)
	1 or 2 times per week		2,849 (30.9%)
	≥3 times per week		1,935 (21.0%)

HR, heart rate; RHR, resting heart rate; DBP, diastolic blood pressure; SBP; systolic blood pressure

Motor- and coordination-related physical fitness statuses were evaluated based on muscular strength, muscular endurance, flexibility, power, agility, and ability to maintain balance, as determined using grip strength (kilograms), number of sit-ups completed (repetitions/minute), sit-and-reach score (centimeters), vertical jump height (centimeters), number of side steps performed (repetitions/30 seconds), and 1-leg standing with eyes open (seconds), respectively. The mean of 3 measurements was recorded for all parameters.

For grip strength (muscular strength, in kilograms), a grip strength dynamometer (Helmas-SH-9600D; South Korea), which is made with a potentiometer control system, was used, measuring the maximum force each subject used to grab its lever.

For sit-ups (muscular endurance), the subjects were required to lie on the sit-up board (Helmas-

SH-9600N; Korea), bend their knees to 90 degrees, grab their necks with both hands, and raise their upper body and bend forward, using only their abdominal muscles. The action was repeated for 1 minute, counting the number of sit-ups within the period.

For the sit-and-reach test (flexibility), the subjects sat on the flexibility measuring instrument (Helmas-SH-9600G; South Korea), spread their heels approximately 5 cm, make their heels come to the edge, stretch their knees straight, bend their backs forward, and naturally make the measuring instrument board move forward.

For vertical jump height (power, in centimeters), the subjects were required to jump as high as possible from a vertical jump board (Helmas-SH-9600F; South Korea).

For the side steps (agility), the subjects were required to stand with 2 feet on the centerline of a long board with parallel lines of 100 cm on both sides (Helmas-SH-9600J; South Korea). The movement was to go over the line on the right, return to the centerline, go over the line on the left, and return to the original position on the centerline. Every time the subject crossed the line was counted as 1, and the total number of times within 30 seconds was counted.

For 1-leg standing with eyes open (balance), the subjects were required to stand on 1 foot on the balance measuring instrument (Helmas-SH-9600H; South Korea), with eyes open, using the preferred leg. We measured the length of time in seconds until the elevated leg touched either the other leg or the ground, or until the 2 hands holding the waist dropped.

Statistical analysis

All the results were summarized as mean ± SD. The univariate analyses were completed with predictor variables after dividing the female subjects into hypertension, prehypertension, and normal groups. One-way analysis of variance or chi-square tests were used to test for differences. Furthermore, if the expected frequency counts in the chi-square test were <5, a Fisher exact test was performed. Multivariate logistic regression analyses were conducted to evaluate cardiovascular respiratory fitness and motor- and coordination-related physical fitness and to determine which variables were significantly related to prehypertension and hypertension as compared with normal tension, after adjusting for age, BMI, alcohol intake, smoking frequency, and exercise intensity. Statistical significance was set at $P < 0.05$. All the analyses were performed using SPSS Ver. 12.0 (SPSS, Chicago, IL, USA).

Results

The differences in anthropometry, cardiovascular respiratory fitness, and motor- and coordination-related physical fitness variables according to prehypertension or hypertension status are shown in Table 2. The prehypertension and hypertension groups, compared with the normal group, were statistically older, shorter, and heavier; had higher BMIs, RHRs, and DPs; had lower VO_2max and vital capacity values; had lesser grip strength; completed fewer sit-ups; achieved lower sit-and-reach scores and shorter vertical jump heights; performed fewer side steps; and maintained balance for shorter times, with a statistical significance of $P < 0.001$. These results indicate that the Korean female subjects in the normal tension group had better body composition, cardiovascular respiratory fitness, and motor- and coordination-related physical fitness levels than the prehypertension or hypertension group. In addition, the prehypertension and hypertension groups had a statistically higher drinking frequency per week ($P < 0.01$) and lower occasions of exercise per week ($P < 0.001$).

The results of the multivariate logistic regression analyses for cardiovascular respiratory fitness and motor- and coordination-related physical fitness variables according to hypertension status are shown in Table 3. The results indicate the odds ratios (95% confidence interval [CI]) for prehypertension and hypertension. No statistically significant relationship was found between prehypertension and grip strength ($P = 0.088$), the number of sit-ups completed ($P = 0.424$), vertical jump height ($P = 0.779$), the number of side steps performed ($P = 0.396$), and the 1-leg standing with eyes open (P=0.071).

Table 2: Anthropometry, cardiovascular respiratory fitness, motor- and coordination-related physical fitness, and lifestyle according to prehypertension and hypertension in Korean women (n = 9,216)

Variables		Normal (n = 5,237)	Pre-HT (n = 2,794)	HT (n = 1,185)	F	*P*
	Age (yr)	43.72 ± 9.38	49.51 ± 9.91	54.23 ± 9.72	737.308	<0.001***
Anthropometry	Height (cm)	157.25 ± 5.09	156.55 ± 5.28	155.31 ± 5.40	72.137	<0.001***
	Weight (kg)	56.36 ± 6.93	59.52 ± 7.77	61.24 ± 8.13	305.470	<0.001***
	Body mass index (kg/m²)	22.79 ± 2.60	24.29 ± 2.95	25.37 ± 2.92	558.060	<0.001***
	SBP (mm Hg)	106.96 ± 7.98	127.39 ± 5.83	150.10 ± 11.23	16,751.873	<0.001***
	DBP (mm Hg)	66.54 ± 6.22	78.25 ± 5.54	90.91 ± 7.95	8,567.063	<0.001***
Cardiovascular respiratory fitness	VO_2max (mL/kg/min)	27.14 ± 4.95	25.59 ± 5.28	24.45 ± 5.22	141.760	<0.001***
	RHR (beats/min)	72.97 ± 8.79	75.19 ± 9.79	76.34 ± 10.99	90.054	<0.001***
	Double product (HR × SBP)	7,812.11 ± 1,160.08	9,578.61 ± 1,327.69	11,458.33 ± 1,859.77	4,336.106	<0.001***
	Vital capacity (ℓ)	2.83 ± 0.59	2.68 ± 0.57	2.53 ± 0.53	148.215	<0.001***
Motor- and Coordination-related physical fitness	Grip strength (kg)	28.43 ± 3.73	28.25 ± 3.76	27.98 ± 3.99	7.329	0.001**
	Sit-ups (reps/min)	13.60 ± 5.81	12.14 ± 5.97	11.03 ± 6.11	97.309	<0.001***
	Sit-and-reach (cm)	17.33 ± 8.02	17.51 ± 8.14	17.31 ± 7.99	0.479	0.619
	Vertical jump height (cm)	25.73 ± 7.21	23.09 ± 7.42	21.15 ± 7.04	212.143	<0.001***
	Side steps (reps/30sec)	31.62 ± 5.30	29.90 ± 5.57	27.41 ± 5.61	268.326	<0.001***
	1-leg standing with eyes open (s)	48.84 ± 39.05	36.52 ± 35.17	26.09 ± 28.55	213.083	<0.001***
Body mass index (kg/m²)	Normal <23	3,013 (71.1%)	992 (23.4%)	232 (5.5%)		
	Overweight ≥23 to <25	1,277 (53.3%)	761 (31.7%)	359 (15.0%)	890.103	<0.001***
	Obese ≥25	947 (36.7%)	1,041 (40.3%)	594 (23.0%)		
Smoking	Non-smoker	5,127 (56.9%)	2,728 (30.3%)	1,158 (12.8%)		
	1 or 2 times per week	94 (57.3%)	49 (29.9%)	21 (12.8%)	4.204	0.379
	≥3 times per week	16 (41.0%)	17 (43.6%)	6 (15.4%)		
Drinking	Non-drinker	4,493 (56.7%)	2,415 (30.5%)	1,010 (12.8%)		
	1 or 2 times per week	636 (59.0%)	315 (29.2%)	127 (11.8%)	18.618	0.001**
	≥3 times per week	108 (49.1%)	64 (29.1%)	48 (21.8%)		
Exercise	No exercise	2,350 (53.0%)	1,442 (32.5%)	640 (14.4%)		
	1 or 2 times per week	1,640 (57.6%)	877 (30.8%)	332 (11.6%)	76.960	<0.001***
	≥3 times per week	1,247 (64.4%)	475 (24.5%)	213 (11.0%)		

Data are expressed as mean ± standard deviation or n (%).
HT, hypertension; HR, heart rate; RHR, resting heart rate; DBP, diastolic blood pressure; SBP; systolic blood pressure/ **P* < 0.05 ***P* < 0.01 ****P* < 0.001, tested by one-way analysis of variance or chi-square test

However, when VO_2max increased by 1 mL/kg/min, the prehypertension prevalence decreased 0.983 times (0.972–0.994, *P* = 0.002). When RHR increased by 1 beat per minute, the prehypertension prevalence was 1.040 times higher (1.034–1.045, *P* < 0.001). When DP increased by 1 unit, the prehypertension prevalence increased 1.001 times (1.001–1.001, *P* < 0.001). As vital capacity increased by 1 ℓ, prehypertension prevalence decreased 0.850 times (0.777–0.930, P < 0.001). An increase in sit-and-reach score of 1 cm increased prehypertension prevalence 1.007 times (1.000–1.013, P = 0.045).

Table 3: The results of the multivariate logistic regression analysis for cardiovascular respiratory fitness, and motor- and coordination-related physical fitness according to prehypertension and hypertension in Korea women (n=9,216)

Variables		Normal vs. Pre-HT			Normal vs. HT		
		OR	95% CI	P	OR	95% CI	P
Cardiovascular respiratory fitness	VO_2max (mL/kg/min)	0.983	0.972-0.994	0.002**	0.966	0.949-0.984	<0.001***
	RHR (beats/min)	1.040	1.034-1.045	<0.001***	1.055	1.047-1.064	<0.001***
	Double product (HR × SBP)	1.001	1.001-1.001	<0.001***	1.002	1.002-1.002	<0.001***
	Vital capacity (ℓ)	0.850	0.777-0.930	<0.001***	0.669	0.580-0.771	<0.001***
Motor- and coordination-related physical fitness	Grip strength (kg)	1.012	0.998-1.026	0.088	1.020	0.999-1.040	0.056
	Sit-ups (repetitions/min)	0.996	0.987-1.006	0.424	0.989	0.975-1.004	0.140
	Sit-and-reach (cm)	1.007	1.000-1.013	0.045*	1.013	1.003-1.023	0.012*
	Vertical jump height (cm)	1.001	0.993-1.010	0.779	1.011	0.997-1.025	0.121
	Side steps (repetitions/30 s)	0.995	0.984-1.006	0.396	0.968	0.952-0.985	<0.001***
	1-leg standing with eyes open (s)	0.999	0.997-1.000	0.071	0.995	0.993-0.998	0.001**

OR, odd ratio; CI, confidence interval; HR, heart rate; RHR, resting heart rate; SBP, systolic blood pressure; HT, hypertension
*P < 0.05 **P < 0.01 ***P < 0.001, tested by multivariate logistic regression analysis, adjusting for age, body mass index, drinking frequency, smoking intensity, and exercise intensity

Furthermore, no statistically significant difference was found between hypertension and grip strength (P = 0.056), the number of sit-ups completed (P = 0.140), and vertical jump height (P = 0.121). However, when the VO_2max increased by 1 mL/kg/min, the hypertension prevalence decreased 0.966 times (0.949–0.984, P < 0.001). When the RHR increased by 1 beat per minute, the hypertension prevalence was 1.055 times higher (1.047–1.064, P < 0.001). As DP increased by 1 unit, hypertension became 1.002 times more prevalent (1.001–1.002, P < 0.001). After the vital capacity increased by 1 liter, the hypertension prevalence decreased 0.669 times (0.580–0.771, P < 0.001). An increase in sit-and-reach score of 1 cm increased the hypertension prevalence 1.013 times (1.003–1.023, P = 0.012). When the number of side steps performed increased by 1 repetition per 30 seconds, hypertension prevalence decreased 0.968 times (0.952–0.985, P < 0.001). When the time to maintain balance increased by 1 second, the hypertension prevalence decreased 0.995 times (0.993–0.998, P = 0.001).

Discussion

This study found that all the cardiovascular respiratory fitness variables and half of the motor- and coordination-related physical fitness variables were closely related with hypertension status.

According to a study, regular physical activity or exercise decreases blood pressure (17-19), implying its potential to decrease the prevalence of hypertension. Moreover, Williams (20) reported that in addition to regular physical activity to prevent hypertension, physical fitness level is also an important independent risk factor of hypertension associated with CVD. Therefore, we distinguished the importance of the physical fitness variables for the prevention and treatment of hypertension. Accordingly, our retrospective cohort study focused on physical training and physical fitness categories to demonstrate the importance of fitness level in preventing hypertension.

In cardiovascular respiratory fitness, the increased RHR and DP increased the prevalence of hypertension, whereas the decreased VO_2max and vital capacity increased the prevalence of hypertension, proving that cardiovascular respiratory fitness is closely related to hypertension. Jouven et al. (21) argued that when RHR is increased, the incidence of sudden death from myocardial infarction and all-cause death would increase several times because heart rate responses are under the control of the autonomic nervous system and vagal activity.

Myocardial infarction is known to be closely related to hypertension, and RHR is closely related to myocardial infarction (21). Therefore, when regular exercise shifts the autonomic balance through an adequate increase in vagal activity, it can significantly improve long-term prognosis (22-23).

VO_2max and vital capacity are closely related to each other. The present research demonstrate that low VO_2max and vital capacity increased the prevalence of hypertension, implying that low cardiovascular respiratory fitness is an important indicator of hypertension. In motor- and coordination-related physical fitness, when scores in agility (side steps) and 1-leg standing with eyes open (balance) increased by 1 unit, the prevalence of hypertension decreased.

Meanwhile, it was interesting to observe that the increasing flexibility (sit-and-reach test) increased the prevalence of prehypertension and hypertension as well. Vivian (10) reported that people with bulky muscles or obese people with high body fat content are commonly thought to be inflexible because they have thicker waists and shorter limbs but that obese people are not necessarily always inflexible. On the contrary, Vivian (10) insisted that obese people could be more flexible because their ligament degradation allows them to be more flexible. It is also important to note that high blood pressure and obesity tend to co-occur (24). Therefore, we thought that the increase in the prevalence of hypertension might reflect increasing obesity. Consequently, patients with hypertension might be more flexible than the normal tension group.

Williams (20) argued that physical activity and physical fitness are 2 independent causes of coronary artery disease and that physical fitness is more closely associated with the reduction of the prevalence of hypertension than physical activity. Our results demonstrate that agility (side steps) and 1-leg standing with eyes open (balance) are significantly related to diseases associated with hypertension. However, these findings remain to be validated. Thus, further well-designed studies should be performed in the future to determine the relationship between hypertension status and motor- and coordination-related physical fitness (25).

This study was limited in that it was a cross-sectional study. Thus, we could not examine the cause and effect of hypertension but only its interrelationship with the physical fitness variables. Furthermore, this study did not adjust the statistical analysis for the intensity, type, and time of exercise; consumption of alcohol; and history of smoking. Thus, a study designed with a more accurate data evaluation method needs to be conducted. In addition, the data are not representative of all Korean women because the participants only resided in Seoul, South Korea. Nevertheless, this study comprising 9,216 subjects is the largest to date in Korea. Because of this study, future well-designed and controlled quantitative cohort studies on cardiovascular respiratory fitness, motor- and coordination-related physical fitness, and chronic degenerative disease may be expected to emerge in South Korea.

Conclusion

Through this research, we found that all of cardiovascular respiratory fitness variables and half of the motor- and coordination-related physical fitness variables were closely related with hypertension status. Therefore, to prevent hypertension, regular exercise training is recommended to increase cardiovascular respiratory fitness and motor- and coordination-related physical fitness.

Ethical Considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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