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Original Article

The Relationship between Physical Fitness and Coronary Risk Factor Profiles in Japanese Women

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Abstract

The purpose of this study was to investigate the relationship between physical fitness and coronary risk factor profiles in Japanese women. The subjects were 1,483 women (ages 30 to 69) who participated in a practical health promotion program. After medical examination, physical fitness was evaluated by conducting a symptom limited maximal exercise test by ergometer to measure maximum oxygen uptake (peak$\dot{V}O_2$) with an expired gas analyzer. The subjects were classified into 3 groups (high fitness, moderate fitness, and low fitness) according to age and physical fitness level. The results showed that the subjects in higher fitness groups had lower levels in: body mass index (BMI), percentage of body fat, waist-hip ratio, resting blood pressure, and atherogenic index, and higher HDL-cholesterol compared to those in lower fitness group. Even after adjustment for the effects of age and BMI, the subjects in the higher fitness groups had better coronary risk factor profiles. These results suggest that among Japanese women a high level of physical fitness is related to favorable coronary risk factor profiles.

Key words: peak$\dot{V}O_2$, coronary risk factors, women, physical fitness, life-style

Introduction

The elderly population in Japan has increased rapidly over the past few years[1]. In the present situation, health behavior is considered to be important, not only for preventing diseases and prolonging life, but also for maintaining an active lifestyle and a higher quality of life. Participation in regular exercise elicits a number of favorable effects that contribute to healthy aging. Therefore, health promotion through exercise from youth to one's later years is a key to living a healthy life.

It has been reported in western countries that both men and women with higher physical fitness levels have better coronary risk factor profiles[2,3,4], and that low physical fitness is an important precursor to mortality. By maintaining high physical fitness levels, people can live healthy lives and prevent diseases. Although several studies on the relationship between physical fitness levels and coronary risk factor profiles have been published on Japanese men[5,6,7,8,9], there have been few studies on Japanese women. In particular, the relationship between physical fitness and coronary risk factor profiles in a large number of Japanese women has not been made clear, and therefore must be examined. The purpose of this study was to investigate the relationship between physical fitness and coronary risk factor profiles.

Subjects and methods

Subjects

The subjects in this study were, initially, 1,971 women (ages 30 to 69), who were selected from participants in a practical health promotion program at the Tokyo Metropolitan Health Promotion Center from July 1993 until December 1997. The participants in the practical health promotion program were accepted by a lottery process from a large group of volunteers who had been publicly solicited. Informed consent was obtained from each subject prior to participation. A medical examination and symptom limited maximal exercise test were conducted by bicycle ergometer to measure peak$\dot{V}O_2$ as an indicator of physical fitness level using an expired gas analyzer. From the results of the medical examination and exercise test, those who fit the criteria

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below were excluded from analysis in this study.

Criteria for exclusion are stated below:

1) Subjects who were taking medicine for heart disease or hypertension. (n=188)
2) Subjects who performed their exercise test by something other than ramp protocol. (n=98)
3) Subjects who were unable to reach 85% of the age-specific predicted maximal heart rate (220 minus age in years) because their systolic blood pressure reached more than 250mmHg; because of a particular electrocardiographic abnormality, such as an increase in premature ventricular contractions, or because of physical problems such as fatigue, leg pain, etc. (n=186)
4) Subjects with many data deficiencies. (n=16) After exclusion, 1,483 subjects were selected for analysis in this study.

Methods

1) Measurement of physique, blood pressure, blood sampling, and lung function.

Physique measurements included body height, body weight, body mass index (BMI) (weight in kilograms divided by height in meters squared) , percentage of body fat obtained by the caliper method, using the Nagamine[10] and Brozek et al. equations[11], waist girth, hip girth, and waist-hip ratio (waist girth divided by hip girth). Resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded in the sitting position using a mercury sphygmomanometer. Resting heart rate was calculated from an electrocardiogram conducted at rest.

Fasting blood samples were obtained and analyzed for total serum cholesterol (TC), HDL-cholesterol (HDL-C), triglyceride (TG), fasting plasma glucose, and uric acid. For subjects with less than 400mg/dl TG, LDL-cholesterol (LDL-C) was calculated using the Fridewald formula[12]. For subjects with more than 400mg/dl TG, LDL-C was calculated using the formula "LDL-C=TC-HDL-C-(TG × 0.16)"[13]. Atherogenic index(AI) was calculated by the following formula (TC-HDL-C) / HDL-C [14]. Vital capacity was measured by a lung function test (Chest, D-21FX).

2) 'Life-style' characteristics

'Life-style' characteristics were derived from self-reported questionnaires, as demonstrated below. 'General life-style' = Are you following a daily healthy routine? (yes/no)

'Smoking habit'=Do you smoke? (yes/no)

'Drinking habit'=How many days do you drink alcohol in a week? (0 to 7days)

'Sleeping habit'=How many hours do you sleep?

'Exercise habit'=Do you exercise regularly? (yes/no)

'Working status'=How many days a week, hours a day do you work?

'Breakfast'=How many times do you skip breakfast in a week? (0 to 7days)

'Stress'=Do you feel stress? (yes/no)

Answers to each question were confirmed by nurses, dietitians, and exercise instructors.

3) Measurement of physical fitness

Maximum oxygen uptake (peak$\dot{V}O_2$) per kilogram of body-weight, as an indicator of physical fitness level, was measured on a symptom-limited exercise test by expired gas analyzer (Minato, AE-280s) on a bicycle ergometer (SIMENS, Ergomet) electrocardiographically monitored (Fukuda, ML5000 system). Blood pressure was measured every minute (Nihon Kolin, STBP780P). Exercise tests were performed according to ramp protocols (increasing 10 watts/minute, 15watts/minute, or 20watts/minute). The subjects were instructed to continue the test as long as possible. The end-points for the test were the appearance of either volitional exhaustion such as leg fatigue and shortness of breathe; severe chest pain, SBP higher than 250mmHg, or an abnormal ECG.

Furthermore, we categorized the peak$\dot{V}O_2$ level and compared the coronary risk factor profiles among the groups classified by fitness level.

Three fitness categories were determined by the peak$\dot{V}O_2$ level. First, we divided the subjects into 4 groups according to their age (ages 30-39, 40-49, 50-59, 60-69). The least fit one-third of the subjects in each group were classified as the low fitness group, the next one-third as the moderate fitness group, and the remaining one-third as the high fitness group. Finally, all high fitness (n=435), moderate fitness (n=459), and low fitness groups (n=444) were put together.

4) Statistical analysis

To clarify the relationship between the coronary risk factor profiles and peak$\dot{V}O_2$, with peak$\dot{V}O_2$ as the dependent variable and the coronary risk factor profiles (physique, blood pressure, blood lipids, blood glucose, and vital capacity) as independent variables, correlation analysis by the univariate statistical model was performed. Furthermore, with peak$\dot{V}O_2$ as the dependent variable and the coronary risk factor profiles as independent variables, correlation analysis by the multivariate model was performed, adjusted for the effects of age and/or BMI which have been reported to affect $\dot{V}O_2$max or peak$\dot{V}O_2$ on other risk factor profiles[15,16].

The coronary risk factor profiles of the 3 fitness groups were compared using a one-way analysis of variance (post-hoc test analysis, Sheffe method). The analysis of covariance was also performed, using age and BMI as multiple covariates (post-hoc test analysis, Bonferroni method).

'Life-style' characteristics were compared using the chi-square test.

For this investigation, a probability of .05 was used as the level for significance.

Results

1) Physical characteristics

The mean age of the subjects was 49.3 ± 10.5 years. Table 1 shows the physical characteristics of all subjects. Each mean datum was within the normal range, except for the mean value of percentage of body fat which was above the normal range[17].

2) Peak$\dot{V}O_2$

Table 2 shows the mean Peak$\dot{V}O_2$ data for each age and fitness group (high fitness, moderate fitness, and low fitness). Mean Peak$\dot{V}O_2$ fell by 2ml/kg/min in each age group from the youngest to the oldest.

3) 'Life-style' characteristics

Table 3 shows the 'life-style' characteristics of the subjects.

Table 1 Subject characteristics (n=1,483)

Parameters	Mean ± SD
Age (years)	49.3 ± 10.5
Body mass index (kg/m^2)	23.2 ± 3.7
% body fat (%)	32.1 ± 8.6
Waist-hip ratio*	0.79 ± 0.06
Resting HR (beats/min)	65 ± 10
Resting SBP (mmHg)	125 ± 18
Resting DBP (mmHg)	78 ± 11
Total cholesterol (mg/dl)	216.3 ± 39.1
HDL-cholesterol (mg/dl)	64.0 ± 15.5
LDL cholesterol (mg/dl)	132.7 ± 36.5
Triglyceride (mg/dl)	99.2 ± 70.1
Atherogenic index	2.6 ± 1.1
Fasting plasma glucose (mg/dl)	91.8 ± 13.0
Uric acid (mg/dl)	4.2 ± 1.0
Peak$\dot{V}O_2$ (ml/kg/min)	26.3 ± 4.6
Vital capacity (l)	2.9 ± 0.5

*n=1,016
HR=Heart rate
SBP=Systolic blood pressure
DBP=Diastolic blood pressure

Table 2 Peak$\dot{V}O_2$ by age and fitness group (n=1,483)

Age group (years)	Mean ± SD (ml/kg/min)	Fitness group	Range (ml/kg/min)	Mean ± SD (ml/kg/min)
30 ~ 39		low (n=105)	19.0 ~ 26.9	24.3 ± 2.1
(n=319)	29.2 ± 4.6	moderate (n=107)	27.0 ~ 31.1	28.9 ± 1.2
		high (n=107)	31.2 ~ 44.9	34.3 ± 2.7
40 ~ 49		low (n=135)	16.3 ~ 25.3	22.8 ± 1.9
(n=405)	27.3 ± 4.3	moderate (n=137)	25.4 ~ 28.6	27.0 ± 1.0
		high (n=133)	26.7 ~ 43.2	32.1 ± 2.8
50 ~ 59		low (n=149)	13.9 ~ 23.5	21.1 ± 1.8
(n=459)	25.4 ± 4.1	moderate (n=161)	23.6 ~ 26.6	25.1 ± 0.9
		high (n=149)	26.7 ~ 43.4	30.0 ± 2.7
60 ~ 69		low (n=101)	15.7 ~ 21.6	19.8 ± 1.4
(n=459)	23.4 ± 3.4	moderate (n=102)	21.7 ~ 24.8	23.3 ± 0.9
		high (n=97)	24.9 ~ 32.7	27.3 ± 1.9

The results showed no significant difference among the 3 fitness groups in the percentage of subjects who answered that they were following a healthy daily routine, smoked, drank alcohol more than once a week, skipped breakfast more than once a week, and felt stress. However, the percentage of subjects who answered that they exercised regularly was significantly different among the 3 fitness groups. In the higher fitness groups, the percentage of subjects who exercised regularly was significantly higher.

4) Exercise test results

The mean peak$\dot{V}O_2$ was 26.3 ± 4.6ml/kg/min. During exercise testing, the mean value of maximal SBP was 201mmHg, maximal DBP was 102mmHg, maximal heart rate was 166beats/min, percent age-specific predicted maximal heart rate (maximal heart rate/age-specific predicted maximal heart rate × 100) was 97.5%, and maximal rate pressure product was 33,387 mmHg·beats/min.

5) Examination of the relationship between exercise test results and coronary risk factor profiles

The univariate correlation coefficients and partial correlation coefficients between peak$\dot{V}O_2$ (dependent variable) and coronary risk factor profiles (independent variables) are shown in Table 4. After adjustment for the effects of age and BMI, percent body fat ($p<0.001$), resting heart rate ($p<0.001$), SBP ($p<0.001$), DBP ($p<0.01$), TG ($p<0.001$), AI ($p<0.001$), and fasting plasma glucose ($p<0.05$) were found to be significantly inversely related to peak$\dot{V}O_2$, while HDL-C ($p<0.001$) and vital capacity ($p<0.01$) were found to be significantly positively related to peak$\dot{V}O_2$.

Table 5 shows the results of a one-way analysis of variance of how coronary risk factor profiles differ according to fitness groups. We observed that there were significant differences in BMI, percentage of body fat, waist-hip ratio, resting heart rate, SBP, DBP, HDL-C, LDL-C, TG, AI, fasting plasma glucose, uric acid, and vital capacity (all variables; $p<0.001$) among the 3 fitness groups. Those in the higher fitness group had lower BMI, percentage of body fat, waist-hip ratio, resting heart rate, SBP, DBP, TG, AI, and higher HDL-C compared to the moderate and low fitness group. However, there was no significant difference in TC among the 3 groups.

Table 6 shows the mean values of coronary risk factor profiles, adjusted for the effects of covariates. We observed that

Table 3 Life style characteristics by fitness group (n=1,483)

Items	Total group (n=490)	low fitness group (n=507)	moderate fitness group (n=486)	high fitness	p value
Following a daily healthy routine (%)	76.8	76.8	79.4	74.1	n.s.
	(1,106/1,440)	(367/478)	(390/491)	(349/471)	
Smoke cigarettes (%)	10.1	9.7	9.8	10.9	n.s.
	(145/1,432)	(46/474)	(48/488)	(51/470)	
Drink more than once a week (%)	40.7	41.5	42.1	38.4	n.s.
	(553/1,359)	(186/448)	(196/466)	(171/445)	
Exercise regularly (%)	54.8	45.5	53.2	65.7	p<0.001
	(780/1,423)	(211/464)	(259/487)	(310/472)	
Skip breakfast more than once a week (%)	26.9	28.6	27.5	24.6	n.s.
	(398/1,479)	(140/489)	(139/506)	(119/484)	
Feel stress (%)	55.4	56.0	56.6	53.5	n.s.
	(672/1,213)	(232/414)	(233/412)	(207/387)	
Sleeping time (hours/day)	6.6 ± 1.0	6.6 ± 1.0	6.7 ± 1.1	6.6 ± 1.0	n.s.
	(n=1,483)	(n=476)	(n=491)	(n=470)	

there were significant differences in percentage of body fat ($p<0.001$), resting heart rate ($p<0.001$), SBP ($p<0.001$), DBP ($p<0.05$), HDL-C ($p<0.001$), LDL-C ($p<0.01$), TG ($p<0.01$), AI ($p<0.001$), fasting plasma glucose ($p<0.05$), and vital capacity ($p<0.001$) among the 3 fitness groups. Those in the high fitness group had a lower percentage of body fat, resting heart rate, systolic BP, diastolic BP, TG, AI, and higher HDL-C than those in the low fitness group after adjustment for the effects of age and BMI.

These results indicate that subjects in the higher fitness group had favorable coronary risk factor profiles.

Table 4 Correlation analysis on coronary risk factor profiles with Peak$\dot{V}O_2$ (n=1,483)

Independent variables	Simple R	Partial R1	Partial R2	Partial R3
Age	-0.453 ***	...	-0.488 ***	...
Body mass index (BMI)	-0.366 ***	-0.412 ***	...	...
% body fat	-0.387 ***	-0.443 ***	-0.163 ***	-0.201 ***
Waist-hip ratio	-0.389 ***	-0.290 ***	-0.224 ***	-0.026
Resting HR	-0.176 ***	-0.179 ***	-0.158 ***	-0.160 ***
Resting SBR	-0.360 ***	-0.213 ***	-0.285 ***	-0.094 ***
Resting DBP	-0.286 ***	-0.196 ***	-0.194 ***	-0.072 **
Total cholesterol	-0.237 ***	-0.067 *	-0.211 ***	-0.016
HDL-cholesterol	0.250 ***	0.271 ***	0.150 ***	0.161 ***
LDL-cholesterol	-0.267 ***	-0.122 ***	-0.222 ***	-0.050
Triglyceride	-0.239 ***	-0.174 ***	-0.175 ***	-0.093 ***
Atherogenic index	-0.337 ***	-0.254 ***	-0.254 ***	-0.143 ***
Fasting plasma glucose	-0.222 ***	-0.131 ***	-0.173 ***	-0.063 *
Uric acid	-0.185 ***	-0.140 ***	-0.085 ***	-0.017
Vital capacity	0.305 ***	0.102 ***	0.307 ***	0.084 **

*** : $p<0.001$ HR=Heart rate
** : $p<0.01$ SBP=Systolic blood pressure
* : $p<0.05$ DBP=Diastolic blood pressure
Partial R1=Partial correlation coefficient when age was adjusted as a covariate
Partial R2=Partial correlation coefficient when BMI was adjusted as a covariate
Partial R3=Partial correlation coefficient when age and BMI were adjusted as covariates

Discussion

1) Distinctive features of the subjects

Each mean datum of physical characteristics of all the subjects was within the normal range, except for the mean value of percentage of body fat. They were apparently healthy but slightly obese[17]. The Japanese National Nutrition Survey in 1997 [18] showed that the percentage of Japanese women who exercise regularly (more than twice a week, more than 30 minutes at one time, and maintaining that pattern for more than 1 year) was 22.3%, while in our sample the percentage of people who exercised regularly was 54.8%. Although the definition of regular exercise in our study did not specify frequency and duration, the rate in our sample was higher than that of the National Survey. Therefore, the sample population of this study consisted of slightly obese but apparently healthy urban Japanese women. The sample may have included a greater proportion of health-conscious people than the general population since the subjects were volunteers for a health promotion course.

2) Physical fitness measured in our study

It is considered that maximal oxygen uptake ($\dot{V}O_2max$) is the best parameter to measure physical fitness level. There are two ways to measure $\dot{V}O_2max$, the direct method and the indirect method. Both methods have advantages and disadvantages. The direct method gives the most accurate results but poses a potential health risk for the subjects. In the indirect method, $\dot{V}O_2max$ is predicted using a formula from the heart rate response to a sub-maximal exercise test. This method is technically easy and the sub-maximal exercise may be less dangerous [19]. The formula to predict $\dot{V}O_2max$ is based on the hypothesis that $\dot{V}O_2max$ increases linearly with heart rate, and the heart rates of people of the same age are regarded as the same at the maximal exercise level. Therefore, measurement of $\dot{V}O_2max$ by the indirect method is less valid.

In this study, we decided to use Peak$\dot{V}O_2$ obtained from the direct method as a measure for physical fitness. Peak$\dot{V}O_2$ is

Table 5 Coronary risk factor profiles of fitness groups (n=1,483)

	low fitness group n=490	moderate fitness group n=507	high fitness group n=486	p value
Age (year)	49.8 ± 10.4	49.4 ± 10.4	48.8 ± 10.5	
Body mass index (kg/m^2)	25.0 ± 4.2	22.9 ± 3.1 ***	21.8 ± 2.8 ###,†††	$p<0.001$
% body fat (%)	36.1 ± 9.1	31.6 ± 7.5 ***	28.4 ± 7.2 ###,†††	$p<0.001$
Waist-hip ratio	0.81 ± 0.06	0.79 ± 0.06 ***	0.77 ± 0.06 ###,††	$p<0.001$
Resting HR (beat/min)	67 ± 10	65 ± 10 *	63 ± 10 ###,††	$p<0.001$
Resting SBP (mmHg)	129 ± 19	125 ± 17 ***	120 ± 17 ###,†††	$p<0.001$
Resting DBP (mmHg)	81 ± 11	78 ± 11 ***	76 ± 10 ###,††	$p<0.001$
Total cholesterol (md/dl)	218.7 ± 38.5	215.6 ± 37.9	214.5 ± 40.8	$p<0.001$
HDL-cholesterol (md/dl)	59.1 ± 13.5	64.3 ± 15.4 ***	68.6 ± 16.0 ###,†††	$p<0.001$
LDL-cholesterol (md/dl)	137.1 ± 36.6	132.1 ± 34.5	128.8 ± 38.0 ##	$p<0.01$
Triglyceride (md/dl)	114.1 ± 81.4	97.2 ± 64.6	86.4 ± 60.1 ###,†	$p<0.001$
Atherogenic index	2.9 ± 1.2	2.5 ± 1.1 ***	2.3 ± 1.0 ###,††	$p<0.001$
Fasting plasma glucose (mg/dl)	94.1 ± 16.2	91.3 ± 11.1 **	90.1 ± 10.5 ###	$p<0.001$
Uric acid (mg/dl)	4.3 ± 1.0	4.1 ± 0.9 **	4.0 ± 0.9 ###	$p<0.001$
Vital capacity (l)	2.8 ± 0.5	3.0 ± 0.5 **	2.9 ± 0.5 #	$p<0.001$
Peak$\dot{V}O_2$ (ml/kg/min)	22.0 ± 2.4	26.0 ± 2.2 ***	31.0 ± 3.5 ###,†††	$p<0.001$

low fitness group vs. moderate fitness group ***$p<0.001$, **$p<0.01$, *$p<0.05$
low fitness group vs. high fitness group ###$p<0.001$, ##$p<0.01$, #$p<0.05$
moderate fitness group vs. high fitness group ††† $p<0.001$, ††$p<0.01$, †$p<0.05$
HR=Heart rate
SBP=Systolic blood pressure
DBP=Diastolic blood pressure

Table 6 Coronary risk factor profiles of fitness groups adjusted mean values[b] (n=1,483)

	low fitness group n=490	moderate fitness group n=507	high fitness group n=486	p value
% body fat (%)	32.9 ± 5.1	32.2 ± 4.7	31.0 ± 4.9 ###,†††	p<0.001
Waist-hip ratio	0.79 ± 0.05	0.79 ± 0.04	0.79 ± 0.04 ###,†	
Resting HR (beat/min)	66 ± 10	65 ± 10 *	63 ± 10 ###,†	p<0.001
Resting SBP (mmHg)	129 ± 16	124 ± 16	121 ± 16 ###,†	p<0.001
Resting DBP (mmHg)	79 ± 10	78 ± 10	77 ± 10 ###	p<0.05
Total cholesterol (md/dl)	215.8 ± 37.0	215.9 ± 35.6	217.1 ± 36.4	
HDL-cholesterol (md/dl)	61.1 ± 15.1	63.9 ± 14.6 **	67.0 ± 15.0 ###,††	
LDL-cholesterol (md/dl)	133.5 ± 34.8	132.5 ± 33.3	131.9 ± 34.2	p<0.01
Triglyceride (md/dl)	107.3 ± 69.7	98.3 ± 67.1	92.1 ± 68.9 ##	p<0.01
Atherogenic index	2.7 ± 1.1	2.6 ± 1.1 *	2.4 ± 1.1 ###	p<0.01
Fasting plasma glucose (mg/dl)	93.0 ± 12.8	91.4 ± 12.4	91.0 ± 12.8	p<0.05
Uric acid (mg/dl)	4.2 ± 0.9	4.1 ± 0.9	4.1 ± 0.9	
Vital capacity (l)	2.9 ± 0.4	3.0 ± 0.5 **	2.9 ± 0.4	p<0.01
Peak$\dot{V}O_2$ (ml/kg/min)	22.3 ± 2.0	26.0 ± 2.0 ***	30.7 ± 2.0 ###,†††	p<0.001

values adjusted for age and body mass index: b
low fitness group vs. moderate fitness group ***p<0.001, **p<0.01, *p<0.05
low fitness group vs. high fitness group ###p<0.001, ##p<0.01, #p<0.05
moderate fitness group vs. high fitness group ††† p<0.001, ††p<0.01, †p<0.05
HR=Heart rate
SBP=Systolic blood pressure
DBP=Diastolic blood pressure

defined as maximal oxygen consumption obtained at the maximal exercise level, while $\dot{V}O_2$max is established, using leveling off as a criterion, as maximal oxygen consumption[20]. For this reason, peak$\dot{V}O_2$ does not always equal $\dot{V}O_2$max. It is generally considered that when subjects use their legs for an incremental exercise test, peak$\dot{V}O_2$ is quite similar to $\dot{V}O_2$max[21]. In our study, the mean percent predicted maximal heart rate of the subjects was 97.5%. Therefore, we assumed that peak$\dot{V}O_2$ data in our study was able to be adopted to represent the physical fitness level instead of $\dot{V}O_2$max because of the attainment of a sufficient exercise level.

3) Peak$\dot{V}O_2$ and coronary risk factor profiles

When an investigation is done on the relationship between peak$\dot{V}O_2$ level and blood pressure and blood lipids, smoking habits and alcohol consumption must be considered as confounding factors, as smoking and drinking have effects on blood pressure, blood lipids and peak$\dot{V}O_2$[22]. Though it has been reported in some studies that smokers have significantly lower $\dot{V}O_2$max than non-smokers[22, 23, 24, 25], in our sample, there was no significant difference in peak$\dot{V}O_2$ between smokers and non-smokers or drinkers and non-drinkers (data not shown). There were no significant differences in the percentage of smokers and drinkers among the 3 fitness groups. Therefore, smokers and drinkers were included for all of the analyses.

Obesity is one of the main coronary risk factors[26]. The results of our study showed that all three parameters for obesity (i.e. BMI, percentage of body fat, and waist-hip ratio) were lower in the higher fitness group. These results suggest that it may be possible to prevent obesity by maintaining a higher fitness level.

Individuals in the range of high normal blood pressure (SBP : 130-139mmHg, DBP : 85-89mmHg) have a greater possibility of developing hypertension and are subject to future risks to targeting organs. Reports by Neaton J.D.[27] and the National High Blood Pressure Education Program report[28] state that high normal blood pressure should be lowered to prevent arteriosclerosis. Looking at the data in our study, the mean SBP was in the normal blood pressure range in all fitness groups. However, in the high fitness group, the mean SBP was 9mmHg lower than that of the low fitness group. Even after the adjustment for age and BMI, there still remained a 6mmHg difference in the mean SBP between the subjects in the high and the low fitness group. These results suggest that even in the people with normal blood pressure, maintaining a high fitness level is important for keeping a favorable blood pressure state.

In our study, a significant relationship between peak$\dot{V}O_2$ and TC was not found after adjusting for age and BMI. This is similar to the results reported in previous studies on women both in Western countries and in Japan[2, 3, 6, 29, 30, 31, 32]. Sedgwick et al[2] reported a significant inverse relationship between predicted peak$\dot{V}O_2$ and SBP and DBP, but no significant relationship between predicted peak$\dot{V}O_2$ and TG and TC in women, by using multiple regression analysis adjusting for age, physique, and life-styles. In addition, a Japanese study of 207 women reported a significant relationship between predicted peak$\dot{V}O_2$ and SBP and HDL-C, but no significant relationship between predicted peak$\dot{V}O_2$ and DBP, TG, TC, and AI was found by multiple regression analysis adjusting for age and percentage of body fat[6]. Many studies generally agree that high fitness does not reduce TC after appropriately adjusting for age and physique in both men and women[33]. As sex hormones, especially estrogen may affect the relationship between exercise and lipid metabolism in women, we tried to separate the subjects into premenopausal and menopausal, and analyzed the relationship between peak$\dot{V}O_2$ and coronary risk factor profiles separately (data not shown). The results showed that all the higher fitness group's lipid profiles except TC were better regardless of menopause. Therefore, the lack of a relationship between TC and peak$\dot{V}O_2$ was unable to be explained by menopause.

The inverse relationship of HDL-C and the incidence of coronary heart disease was reported in the Framingham study[34] and the Multiple Risk Factor Intervention Trial (MRFIT)[35]. It was also reported by Gordon et. al. that a 1mg/dl increment in HDL-C was associated with significant 2-3% decreases in cardiovascular disease mortality rates[36]. Recent studies[37,38,39,40] in Caucasian males have demonstrated the importance of triglyceride levels as an independent risk factor for cardiovascular disease. The American College of Sports Medicine's Guidelines reported the benefits of regular exercise which are well established, two of which are increased HDL-C and decreased TG[41]. Our results showed a significant correlation between peak$\dot{V}O_2$ and HDL-C, and a significant inverse correlation between peak$\dot{V}O_2$ and TG, even after an adjustment for age and physique. As we mentioned above, the results in our study supported the previous studies' results that high physical fitness is good for favorable coronary risk factor profiles.

Recently, some studies[42,43] have shown a strong, graded, and independent association of physical fitness with cardiovascular disease and all-cause mortality. However, in Japanese women, the relationship between mortality and physical fitness is still unclear. Therefore, we should develop our study into a longitudinal study to clarify the causal relationship between physical fitness and mortality or morbidity in Japanese women.

Prior to this study, there were no reports of the relationship between actual measured peak$\dot{V}O_2$ and coronary risk factor profiles in Japanese women. As many elderly people are currently forced to go through life with multiple diseases and high health care costs, there is an immediate need for increased exercise-based health promotion. The results in our study serve as evidence that physical fitness is important to maintaining good health in women.

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