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Effect of aerobic exercise on the atherogenic index of plasma in middle-aged Chinese men with various body weights

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A B S T R A C T

Objective: The aim of this study was to examine the correlation between aerobic exercise and the atherogenic index of plasma (AIP) in middle-aged Chinese men stratified by body weight.

Methods: A cross-sectional study, which recruited 26,701 middle-aged Chinese men undergoing health examinations in our hospital from 1st January 2014 to 30th June 2015 was performed, and the associations between body weight and AIP, and aerobic exercise and AIP were evaluated.

Results: The mean AIP levels were -0.016 ± 0.305, 0.138 ± 0.3171 and 0.211 ± 0.3243 in normal weight, overweight and obese subjects, respectively, and appeared to rise with body weight. Significantly higher AIP levels were observed in subjects with a weekly aerobic exercise period ≥90 min than in those with a weekly aerobic exercise period <90 min, and the mean AIP levels were -0.038 ± 0.3015, 0.117 ± 0.3182 and 0.192 ± 0.3209, and were 0.003 ± 0.3067, 0.156 ± 0.3149 and 0.225 ± 0.3263 in normal weight, overweight and obese men with a weekly aerobic exercise period ≥90 min and <90 min, respectively. In addition, aerobic exercise significantly reduced AIP after adjustment for age, systolic blood pressure, diastolic blood pressure, body mass index (BMI), fasting blood glucose and uric acid.

Conclusions: Lowering body weight and/or increasing aerobic exercise time may reduce AIP, and lowering body weight results in a greater reduction in AIP than aerobic exercise. Weight control combined with increased aerobic exercise time may cause a synergistic effect on the reduction of AIP.

1. Introduction

The 2013 Report on Cardiovascular Diseases in China showed that there were approximately 290 million patients with cardiovascular diseases in China, which ranked as the main cause of death in urban and rural populations (38.7% in rural populations and 41.1% in urban populations) [1]. Obesity has become a major risk factor leading to a rise in the prevalence of cardiovascular diseases [2]. In particular, abdominal obesity is recognized as an independent risk factor of obesity-related diseases and death [3]. The WHO report demonstrated that physical activity confers health benefits including, lowering weight and blood pressure, and improvements in blood lipid and glucose levels [4], and it has been proved that regular physical activity may reduce the risk of developing cardiovascular diseases including coronary heart disease, stroke, type 2 diabetes mellitus, and hypertension [4–6]. In the past two decades, a reduction in the number of deaths due to cardiovascular diseases has been observed in the USA [7]. Therefore, the American Heart Association (AHA) included physically active lifestyles as 1 of the 7 goals for ideal cardiovascular health [8]. However, Chinese people have a low participation rate in physical exercise, and the intensity of physical exercise has markedly declined [9], which challenges health promotion, and the prevention and control of cardiovascular diseases in China. The atherogenic index of plasma (AIP) is an indirect parameter indicative of the size of low-density lipoprotein (LDL) particles [5], and small, dense LDL (sdLDL), a strong risk factor for atherosclerosis, is a more sensitive factor which predicts emergency cardiovascular events [5,6,10–14]. In the 2013 American College of Cardiology (ACC)/AHA Guideline on the Treatment of Blood Cholesterol to Reduce Atherosclerotic Cardiovascular Risk in

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Adults, lipid-lowering therapy is defined as the primary goal of anti-atherosclerosis interventions, and LDL is considered the most important contributor to atherosclerosis [15]. The major purpose of the present study was to evaluate the effect of aerobic exercise on AIP among middle-aged men with various body weights in southeastern China, in order to provide evidence for the development of preventive and control strategies for cardiovascular diseases.

2. Methods

2.1. Subjects

A cross-sectional study was conducted. 32,586 men between 40 and 64 years of age who had health examinations in our hospital between 1 January 2014 and 30 June 2015, were recruited. All recruited subjects resided in the Shanghai, Nanjing, Suzhou, Wuxi, and Changzhou regions of southeastern China. Subjects who used lipid-regulating drugs, had a history of myocardial infarction, stroke, and severe hepatic and renal insufficiency, or incomplete medical records were excluded from the study. Specific exclusion and the number are as follows: incomplete medical records 523 cases; too thin (BMI < 18.5 kg/m^2) or excessively fat (BMI > 36.9 kg/m^2) 296 cases; taking lipid-regulating drugs 2986 cases; myocardial infarction history 306 cases; severe cerebral infarction108 cases; severe liver function damage 85 cases; severe renal dysfunction 72 cases; chronic bronchitis, pulmonary emphysema, pulmonary heart disease and other lung diseases 534 cases; osteoarthrosis 198 cases; anemia 42 cases. A total of 5885 subjects were excluded and finally 26,701 subjects were enrolled in this study.

The study protocol was approved by the Ethics Review Committee of the Taihu Rehabilitation Hospital of Jiangsu Province. Written informed consent was obtained from all participants following a detailed description of the purpose of the study.

2.2. Questionnaire survey

The demographic and clinical characteristics were obtained using a self-designed questionnaire, including age, residency, profession, smoking status, alcohol consumption, salt consumption, living habits, history of chronic diseases (hypertension, diabetes, coronary heart disease, stroke and other cardiovascular diseases), and medications. The questionnaire was administered by well-trained medical professionals.

2.3. Anthropometric and laboratory measurements

The height, weight, waist circumstance (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP), and body mass index (BMI) were recorded for all patients. In addition, all participants were fasted for 8–12 h, and 5 mL of venous blood was collected from the cubital vein the following morning. The serum fasting blood glucose (FBG), triglycerides (TG), total cholesterol (TC), high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), and uric acid (UA) levels were determined using the hexokinase method, the glycerol phosphate oxidase method, the oxidase method, an antibody-based homogeneous assay, the homogeneous assay, and the uricase-peroxidase coupled method on a fully automatically biochemical analyzer (Hitachi 7600; Hitachi, Ltd.; Tokyo, Japan), respectively.

2.4. Definition of aerobic exercise, AIP and body weights group

In this study, aerobic exercise was defined as moderate-intensity (3– 6 MET) physical activity, and included fast walking, jogging, bicycle riding, and swimming. All subjects were assigned to two groups according to the duration and frequency of physical activity: (1) <90 min/w group, no extra physical activity except daily life and work activities or physical activity < three times a week and < 30 min each session or < 90 min of physical activity a week; (2) ≥90 min/w group, physical activity > three a week and > 30 min each session or > 90 min a week.

Body weights group: normal weight, BMI is 18.5–23.9 kg/m^2, overweight: BMI for 24.0–27.9 kg/m^2, obesity: BMI higher than or over 28.0 kg/m^2.

The atherogenic index of plasma (AIP) is defined as the base 10 logarithm of the ratio of the concentration of triglyceride (TG) to high density lipoprotein cholesterol (HDL-C), where each concentration is expressed in mmol/L, i.e. AIP = log10 (TG/HDL-C) [16]. All participants were assigned to one of three groups according to the AIP level. Subjects with an AIP < 0.11, an AIP between 0.11 and 0.21, and an AIP > 0.21 were assigned to the low-, intermediate, and high-risk atherosclerosis groups, respectively [17].

2.5. Statistical analysis

All measurement data are presented as the mean ± standard deviation (SD), while count data are expressed as the number (proportion). Differences in proportions were tested for statistical significance using a chi-square test, and analysis of variance (ANOVA) was used to compare the means among groups. The factors affecting AIP were identified using linear regression analysis. All statistical analyses were performed using SPSS (version 16.0; SPSS, Inc., Chicago, IL, USA), with a P value < 0.05 considered statistically significant.

Table 1
Basic characteristics of subjects.

Index	Subgroup	n	%
Age (years)	40– 49	12,124	45.4
	50– 59	11,008	41.2
	60– 65	3569	13.4
Residence	Urban	17,075	63.9
	Rural	9626	36.1
Aerobic exercise	<90 min/w	14,433	54.1
	≥90 min/w	12,268	45.9
Smoking status	Never or quit >1 year	10,801	40.5
	Quit <1 year	829	3.1
	Current	15,071	56.4
Fasting plasma glucose	Untreated and <5.6 mmol/L	17,990	67.4
	Treated to <5.6 mmol/L or 5.6–7.0 mmol/L	5108	19.1
	>7.0 mmol/L	3603	13.5
Blood pressure	Untreated and < 120/<80 mm Hg	6082	22.8
	Treated to <120/<80 mm Hg or 120–139/80–89 mm Hg	11,883	44.5
	≥140/90 mm Hg	8736	32.7
Body mass index	18.5– 23.9 kg/m^2	9690	36.3
	24.0– 27.9 kg/m^2	1362	5.1
	28.0– 36.9 kg/m^2	3649	13.6
Atherogenic index of plasma	≤0.21	18,129	67.9
	>0.21	8572	32.1

3. Results

3.1. Basic situations and cardiovascular risk factors of subjects

A total of 26,701 subjects were enrolled in this study, and the mean age of subjects is 50.8 ± 6.76; 17,075 subjects (63.9%) were urban and 9626 subjects (36.1%) were rural. 14,433 subjects (54.1%) of exercise time < 90 min per week; 15,071 subjects (56.4%) were smokers; 17,990 subjects (67.4%) have ideal fasting plasma glucose level and 6082 subjects (22.8%) have ideal blood pressure level; 9690 men have a normal body mass index (BMI), 1362 were overweight and 3649 were obese (Table 1). Systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting blood glucose (FBG), total cholesterol (TC), triglyceride (TG), LDL-cholesterol (LDL-C) and uric acid (UC) increased with body weight (all P values < 0.05), while high-density lipoprotein cholesterol (HDL-C) decreased with body weight (all P values < 0.05). In men with a normal BMI, the subjects with a weekly aerobic exercise period ≥90 min had higher SBP, FBG and HDL-C and lower TC and TG than those with a weekly aerobic exercise period < 90 min; among overweight men, the subjects with a weekly aerobic exercise period ≥90 min had higher SBP, FBG and HDL-C and lower TC, TG and LDL-C than those with a weekly aerobic exercise period < 90 min; and in obese men, the subjects with a weekly aerobic exercise period ≥90 min had lower DBP, FBG, TC, TG, LDL-C and UA and higher HDL-C than those with a weekly aerobic exercise period < 90 min (Table 2).

3.2. Correlation between aerobic exercise and AIP in subjects with various body weights

In men with a normal BMI, the subjects with a weekly aerobic exercise period ≥90 min had a significantly lower AIP than those with a weekly aerobic exercise period <90 min (−0.038 ± 0.3015 vs. 0.003 ± 0.3067, P < 0.05), and overweight subjects with a weekly aerobic exercise period ≥90 min had a significantly lower AIP than those with a weekly aerobic exercise period <90 min (0.117 ± 0.3182 vs. 0.156 ± 0.3149, P < 0.05), while obese subjects with a weekly aerobic exercise period ≥90 min had a significantly lower AIP than those with a weekly aerobic exercise period <90 min (0.192 ± 0.3209 vs. 0.225 ± 0.3263, P < 0.05) (Fig. 1).