MAYO CLINIC

ORIGINAL ARTICLE

Association of Exercise Heart Rate Response and Incidence of Hypertension in Men

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Abstract

Objective: To examine the association of heart rate (HR) responses at rest, during exercise, and after exercise with incident hypertension (HTN) in men.

Participants and Methods: A total of 10,418 healthy normotensive men without abnormalities on electrocardiography or a history of myocardial infarction, stroke, cancer, or diabetes underwent a maximal exercise test and were followed up for incidence of HTN. Heart rate reserve was defined as the maximal HR minus resting HR. Heart rate recovery was defined as HR 5 minutes after the exercise test.

Results: During a mean follow-up of 6 years, there were 2831 cases of HTN. Compared with men who had lower HR reserve, the risk of incident HTN was significantly lower for men with higher HR reserve (hazard ratio, 0.84; 95% CI, 0.74-0.95 for the highest quartile vs the lowest quartile of HR reserve; P=.002) when adjusted for age, baseline examination year, smoking, heavy drinking, body mass index, resting blood pressure, cholesterol and glucose levels, and cardiorespiratory fitness. Compared with men who had higher HR recovery, the risk of incident HTN was significantly lower for men with lower HR recovery (hazard ratio, 0.90; 95% CI, 0.80-0.99 for quartile 3 vs highest quartile; P=.04) after adjusting for the aforementioned confounders. However, the overall linear trend for HR recovery was not significant (P=.26).

Conclusion: The risk of HTN decreased in men with higher HR reserve. Therefore, HR reserve may be considered as a useful exercise parameter for predicting the risk of HTN in men.

 ■ Mayo Clin Proc. 2014;89(8):1101-1107

Hypertension (HTN) is the most prevalent risk factor for cardiovascular (CV) disease (CVD) among US adults and affects nearly one-third of the population aged 18 and older.[1,2] The prevalence of HTN has increased by almost one-fourth over the past 15 years among adults in the United States, increasing from 22.2% in 1995 to 27.8% in 2007.[3,4] Risk of stroke, coronary heart disease (CHD), congestive heart failure, and renal failure is also increased in people with HTN.[5] The estimated direct cost of HTN for 2007 was $43.5 billion, a major burden on the US health care system.[6] The World Health Organization report on global health risk indicated that high blood pressure is the leading risk factor for causes of death worldwide.[7]

Considerable data have established the importance of heart rate (HR) characteristics and future CVD. Resting HR (RHR) has consistently been found to be a predictor of HTN, CHD, and other measures of CVD morbidity and mortality.[8-13] Some studies have found that maximal HR is a strong predictor of CVD and all-cause mortality.[14,15] Very few studies, however, have examined the relationship between HR reserve and CVD mortality. We earlier reported that HR reserve predicts CVD mortality in young men independent of cardiorespiratory fitness (CRF).[13] Other studies have found that HR recovery is also a predictor of CVD and all-cause morbidity and mortality.[16,17] Heart rate reserve and HR recovery are parameters influenced by CRF, and CRF also depends on various factors such as CV, lung, and muscle fitness. This distinction may be important because HTN is a CVD risk factor that is less related to pulmonary function and muscle fitness. Therefore, we hypothesized that HR reserve and HR recovery might be important predictors of incident HTN. The purpose of this study was to analyze the association of HR reserve and HR recovery with incident HTN in a group of men who enrolled in the Aerobics Center Longitudinal Study, a prospective epidemiological investigation.

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PARTICIPANTS AND METHODS

Study Population

Participants received a comprehensive health examination at the Cooper Clinic in Dallas, Texas. The Cooper Institute Institutional Review Board reviewed and approved the study annually; details of the study have been published previously.[18,19] Participants came to the Cooper Clinic for preventive medical examinations and counseling regarding exercise, diet, and other lifestyle factors associated with an increased risk of chronic disease. Of the 17,047 men aged 20 years or older who underwent at least 2 examinations including a maximal exercise test on a treadmill during 1974-2003, 10,418 were selected for this analysis. Study participants were predominantly non-Hispanic white (97%), well educated, and from the middle and upper socioeconomic strata. Although the sample came from middle and upper socioeconomic strata, the participants were similar to other well-characterized population-based cohorts in terms of blood pressure, cholesterol level, body weight, and CRF.[20] At baseline, all participants included in the analysis were free of known CVD, cancer, or diabetes; had normal results on resting or exercise electrocardiography (ECG); and achieved an 85% age-predicted maximal HR (220 − age) during the maximal exercise treadmill test. In addition, participants had no known HTN at baseline. The current analysis included only men because the number of women with incident HTN in this population was too small for a meaningful statistical analysis. The Figure details selection of the study population.

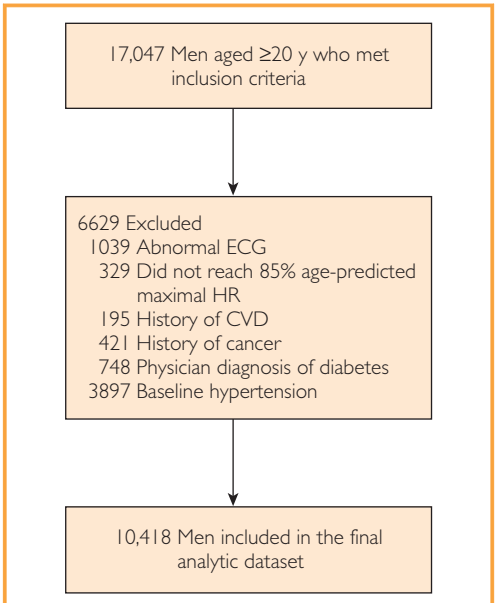

FIGURE. Participant flowchart. Inclusion criteria were age 20 years or older and at least 2 examinations including a maximal exercise test on a treadmill during 1974-2003. CVD = cardiovascular disease; ECG = electrocardiogram; HR = heart rate.

Measurements

The baseline clinical examination was conducted after participants gave their informed written consent and followed an overnight fast of at least 12 hours. The examination consisted of resting blood pressure measurement, blood chemistry analyses, personal and family health history, anthropometry, and a maximal exercise test on a treadmill. Previous reports have described the clinical examination in detail.[18,21,22] Briefly, height and weight were measured on a standard balance beam scale and stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Participants provided self-report of weekly alcohol consumption. Heavy drinking was defined as 14 or more drinks per week. Serum samples were analyzed for lipids and glucose using standardized automated bioassays at the Cooper Clinic Laboratory, which participated in and met quality control criteria of the Centers for Disease Control and Prevention Lipid Standardization Program.

Resting blood pressure was measured in the seated position and was recorded as the first and fifth Korotkoff sounds by auscultatory methods after at least 5 minutes of rest. A standard sphygmomanometer was used, and 2 readings separated by 2 minutes were averaged. If the first 2 readings differed by more than 5 mm Hg, additional readings were obtained and averaged. The maximal exercise test was conducted following a modified Balke protocol.[23] Participants began walking at 88 m/min with no elevation. At the end of the first minute, grade was increased to 2% and thereafter increased 1% per minute until the 25th minute. After 25 minutes, the grade remained constant while the speed increased each subsequent minute by 5.4 m/min. Participants were encouraged to give a maximal effort during the test. Heart

Mayo Clin Proc. ■ August 2014;89(8):1101-1107 ■ http://dx.doi.org/10.1016/j.mayocp.2014.04.022
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