Original Article

Elevated Resting Heart Rate is Associated with Dyslipidemia in Middle-aged and Elderly Chinese

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Abstract

Objective To study the relationship between resting heart rate and blood lipid level.

Methods A total of 9415 subjects aged ≥40 years were included in the present study. Their resting heart rate was monitored and their serum levels of triglyceride (TG), total cholesterol (TC), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C) were measured to define dyslipidemia according to the 2007 Chinese Guidelines on Prevention and Treatment of Dyslipidemia in Adults.

Results The subjects were divided into group A with their resting heart rate <70 beats/min, group B with their resting heart rate =70-79 beats/min, group C with their resting heart rate =80-89 beats/min, and group D with their resting heart rate ≥90 beats/min. High TG, TC, and LDL-C were presented across the resting heart rate (P_trend <0.01). Multiple logistic regression analysis revealed that the risk of high TG and TC was higher in subjects with their resting heart rate ≥90 beats/min than in those with their resting heart rate <70 beats/min (OR=1.42; 95% CI: 1.16-1.74 and OR=1.33; 95% CI: 1.09-1.64, respectively).

Conclusion Elevated resting heart rate is associated with high TG and TC in middle-aged and elderly Chinese subjects.

Key words: Dyslipidemia; Heart rate; Triglyceride; Cholesterol

INTRODUCTION

It was reported that resting heart rate can accurately predict cardiovascular diseases (CVD) and sudden death[1-5]. Resting heart rate is a direct index of body sympathetic and parasympathetic balance[6]. The high risk of CVD attributable to a higher resting heart rate can be partly mediated by the dysfunction of an autonomic system, with a state of sympathetic domination and parasympathetic inhibition. It has been shown that a higher resting heart rate is related with atheroscler-

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osis\cite{7}, diabetes\cite{8-9} and other metabolic disorders\cite{10}, which underlay the progress of CVD. However, few studies are available on the relationship between resting heart rate and dyslipidemia, a main cause of CVD and deaths as a result of CVD\cite{11-12}. The association between resting heart rate and major blood lipids was thus observed in this study.

SUBJECTS AND METHODS

Subjects

This study was approved by the Institutional Review Board of Ruijin Hospital. All participants gave their written informed consent.

A total of 10 375 subjects aged 40 years or older in Jiading district, Shanghai, China, were included in this study. The study was to investigate the lifestyle and environmental risk factors for diabetes and other metabolic disorders. Subjects whose heart rate or blood lipid values were missing, who had a self-reported history of strokes, myocardial infarction or CVD, who used β blockers, digoxin, non-dihydropyridine calcium channel blockers or lipid lowering drugs were excluded from the study. Finally, 9 415 were enrolled in the present study.

Data Collection, Biochemical Analysis

Demographic data, disease history, medication used, physical activity, and lifestyle factors were collected using a standard questionnaire. Physical activity was assessed according to the international physical activity questionnaire short form (IPAQ-SF) and presented as a metabolic equivalent (MET)\cite{13}. MET-hour/week=(3.3×walking hours×walking days+4.0×moderate-intensity activity hours×moderate days+8.0×vigorous-intensity activity hours×vigorous days). Body weight and height were measured without shoes and heavy clothes to 0.1 Kg and 0.1 cm. Body mass index (BMI) was calculated as body weight (Kg) divided by squared body height \((m^2)\). Blood pressure (BP) was measured 3 times at 1 min intervals after at least a 15 min rest. The average of 3 readings was used for analysis. Resting heart rate was recorded and the mean value of the 2rd and 3rd readings was averaged for analysis.

After at least 10 h of overnight fasting, a venous blood sample was collected for biochemical analysis. Fasting plasma glucose (FPG) and serum levels of TG, TC, HDL-C, and LDL-C were measured.

Definition of Dyslipidemias

According to 2007 Prevention Guidelines for Dyslipidemia in Chinese Adults\cite{14}, TG was defined as high when it was ≥2.26 mmol/L, TC was defined as high when it was ≥6.22 mmol/L, LDL-C was defined as high when it was ≥4.14 mmol/L, HDL-C was defined as low when it was <1.04 mmol/L.

Statistical Analysis

The data were analyzed using SAS version 9.3 (SAS Institute, Cary, NC) and expressed as mean±SD. The subjects were divided into group A with their resting heart rate <70 beats/min, group B with their resting heart rate =70-79 beats/min, group C with their resting heart rate =80-89 beats/min, and group D with their resting heart rate ≥90 beats/min. These cutoff points represent low, moderate and high resting heart rates\cite{9,11}. \(P_{trend}\) across different groups was calculated using generalized linear models for continuous variables and using a Cochran-Armitage \(\chi^2\) test for categorical variables. Dyslipidemia was defined according to different cutoff levels. Odds ratio (OR) was estimated using multiple logistic regression models in groups B-D with group A as the reference. An adjusted model was controlled for sex, age, BMI, current smoking and drinking status, physical activity, systolic BP and FPG. \(P<0.05\) was considered statistically significant.

RESULTS

General Characteristics of Subjects

The general characteristics of participants are listed in Table 1. In general, females, young subjects, non-smokers, non-drinkers and diabetics usually had a higher resting heart rate and less physical activities. No apparent trend was found in BMI among the 4 groups (\(P_{trend}=0.4668\)). The SBP, DBP, FPG, and serum levels of TG, TC, LDL-C, and HDL-C increased with resting heart rate levels (\(P_{trend}<0.01\)).

Prevalence of Dyslipidemia

The prevalence of high TG, TC, LDL-C, and low HDL-C is shown in Figure 1. The prevalence of high TG, TC, and LDL-C increased while the prevalence of low HDL-C decreased with resting heart rate (\(P_{trend}<0.0001, P_{trend}=0.0275\)).

Relation between Dyslipidemia and Resting Heart Rate

Multiple logistic regression models showed that resting heart rate was closely related with high TG, TC and LDL-C in group D vs A (OR=1.79, 95% CI:
1.49-2.15; OR: 1.80, 95% CI: 1.49-2.16; OR: 1.41, 95% CI: 1.15-1.73; respectively Table 2). When the age, sex, BMI, physical activity, current smoking and drinking status, SBP, DBP, and FPG into the models were used as potential covariates, the OR in group D was attenuated to 1.42 (95% CI: 1.16-1.74) for high TG, to 1.33 (95% CI: 1.09-1.64) for high TC, and to 1.10 (95% CI: 0.88-1.38) for high LDL-C.

**DISCUSSION**

In the present study, the resting heart rate was related to TG and TC and no apparent relation was observed between resting heart rate and LDL-C or HDL-C, after adjustment for conventional risk factors, thus providing additional evidence for the relation between resting heart rate and blood lipids.

![Figure 1. Prevalence of dyslipidemia in groups A-D. H1: group A; H2: group B; H3: group C; H4: group D.](image)

**Table 1.** General Parameters of Subjects Included in This Study

<table>
<thead>
<tr>
<th>Items</th>
<th>&lt;70 (n=1 527)</th>
<th>70-79 (n=3 235)</th>
<th>80-89 (n=2 763)</th>
<th>≥90 (n=1 890)</th>
<th>P\textsubscript{trend}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>59.2±9.0</td>
<td>57.7±9.2</td>
<td>57.8±9.7</td>
<td>57.9±9.8</td>
<td>0.0023</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>728 (47.7)</td>
<td>1217 (37.6)</td>
<td>966 (35.0)</td>
<td>669 (35.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Smokers, n (%)</td>
<td>482 (32.6)</td>
<td>799 (25.6)</td>
<td>603 (22.7)</td>
<td>388 (21.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Drinkers, n (%)</td>
<td>392 (26.6)</td>
<td>648 (20.7)</td>
<td>543 (20.4)</td>
<td>356 (19.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI (kg/m\textsuperscript{2})</td>
<td>25.02±3.12</td>
<td>25.01±3.09</td>
<td>25.15±3.31</td>
<td>25.03±3.48</td>
<td>0.4668</td>
</tr>
<tr>
<td>METs (h/w)</td>
<td>18.5 (0.0-37.1)</td>
<td>19.8 (0.0-37.9)</td>
<td>16.5 (0.0-34.7)</td>
<td>16.5 (0.0-34.7)</td>
<td>0.0027</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>140.3±20.1</td>
<td>138.4±19.9</td>
<td>140.4±19.5</td>
<td>144.2±20.1</td>
<td>0.0001</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>79.5±9.6</td>
<td>81.1±9.8</td>
<td>83.6±9.9</td>
<td>86.9±10.6</td>
<td>0.0001</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>1.26 (0.89-1.75)</td>
<td>1.33 (0.96-1.92)</td>
<td>1.40 (0.98-1.96)</td>
<td>1.49 (1.04-2.12)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>5.22±0.97</td>
<td>5.30±0.97</td>
<td>5.37±0.99</td>
<td>5.47±1.13</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>LDL-C (mmol/L)</td>
<td>3.13±0.85</td>
<td>3.18±0.86</td>
<td>3.21±0.84</td>
<td>3.22±0.90</td>
<td>0.0022</td>
</tr>
<tr>
<td>HDL-C (mmol/L)</td>
<td>1.32±0.32</td>
<td>1.32±0.31</td>
<td>1.33±0.32</td>
<td>1.35±0.34</td>
<td>0.0063</td>
</tr>
<tr>
<td>FPG (mmol/L)</td>
<td>5.24±1.10</td>
<td>5.35±1.13</td>
<td>5.55±1.49</td>
<td>6.02±2.08</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>179 (11.8)</td>
<td>457 (14.2)</td>
<td>501 (18.2)</td>
<td>486 (25.8)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

**Note.** The data are presented as mean±SD. BMI: body mass index; METs: metabolic equivalent; SBP: systolic blood pressure; DBP: diastolic blood pressure; TG: triglyceride; TC: total cholesterol; LDL-C: low density lipoprotein cholesterol; HDL-C: high density lipoprotein cholesterol; FPG: fasting plasma glucose.

<table>
<thead>
<tr>
<th>Items</th>
<th>&lt;70 (n=1 527)</th>
<th>70-79 (n=3 235)</th>
<th>80-89 (n=2 763)</th>
<th>≥90 (n=1 890)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High TG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude OR</td>
<td>1.00</td>
<td>1.30 (1.10-1.55)</td>
<td>1.45 (1.21-1.73)</td>
<td>1.79 (1.49-2.15)</td>
</tr>
<tr>
<td>Adjusted OR</td>
<td>1.00</td>
<td>1.26 (1.05-1.51)</td>
<td>1.25 (1.03-1.51)</td>
<td>1.42 (1.16-1.74)</td>
</tr>
<tr>
<td>High TC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude OR</td>
<td>1.00</td>
<td>1.30 (1.09-1.54)</td>
<td>1.38 (1.16-1.65)</td>
<td>1.80 (1.49-2.16)</td>
</tr>
<tr>
<td>Adjusted OR</td>
<td>1.00</td>
<td>1.22 (1.02-1.47)</td>
<td>1.17 (0.97-1.42)</td>
<td>1.33 (1.09-1.64)</td>
</tr>
<tr>
<td>High LDL-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude OR</td>
<td>1.00</td>
<td>1.16 (0.96-1.41)</td>
<td>1.17 (0.96-1.43)</td>
<td>1.41 (1.15-1.73)</td>
</tr>
<tr>
<td>Adjusted OR</td>
<td>1.00</td>
<td>1.10 (0.90-1.34)</td>
<td>0.99 (0.80-1.22)</td>
<td>1.10 (0.88-1.38)</td>
</tr>
<tr>
<td>Low HDL-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude OR</td>
<td>1.00</td>
<td>0.90 (0.77-1.06)</td>
<td>0.79 (0.67-0.94)</td>
<td>0.85 (0.71-1.02)</td>
</tr>
<tr>
<td>Adjusted OR</td>
<td>1.00</td>
<td>0.95 (0.80-1.13)</td>
<td>0.85 (0.71-1.02)</td>
<td>0.91 (0.74-1.11)</td>
</tr>
</tbody>
</table>

**Note.** TG: triglyceride; TC: total cholesterol; LDL-C: low density lipoprotein cholesterol; HDL-C: high density lipoprotein cholesterol. Adjusted OR was controlled for age, sex, BMI, physical activity, current smoking and drinking status, SBP, DBP, and FPG.
It was reported that resting heart rate can predict CVD and sudden death\textsuperscript{[1-5,15]}. The predictive power of resting heart rate even overwhelsmes other established risk factors, such as smoking status, blood pressure and blood glucose\textsuperscript{[16-17]}. Elevated resting heart rate is associated with diabetes\textsuperscript{[8-9,18-19]}, atherosclerosis\textsuperscript{[2,20]} and other metabolic disorders\textsuperscript{[10]}. However, evidence for the relationship between heart rate and dyslipidemia is scarce. To the best of our knowledge, only two studies\textsuperscript{[11-12]} reported the relationship between resting heart rate and blood lipids. It was reported that non-HDL cholesterol level was 14.5% higher and TG level was 36.3% higher in males with their resting heart rate ≥90 beats/min than in those with their resting heart rate <60 beats/min (12.5% and 22.2% higher in corresponding females)\textsuperscript{[11]}. Another study\textsuperscript{[12]} demonstrated a significant relationship between heart rate with TC and TG level, and an inverse relationship between heart rate and HDL-C level, which are consistent with the findings in the present study. Resting heart rate is an indicator of body autonomic function. A higher resting heart rate represents a state of sympathetic stimulation and parasympathetic inhibition\textsuperscript{[21]}. Such an imbalance of the autonomic system is related with hypertension\textsuperscript{[22]}, diabetes\textsuperscript{[23]}, and dyslipidemia\textsuperscript{[24]}. It seems more reasonable that elevated heart rate and dyslipidemia share some common environmental and biological pathways, such as aging, obesity, hypertension and less physical activity and related body neuroendocrine changes, influencing autonomic heart rate and lipid metabolism. However, adjustment for those risk factors did not markedly alter the association observed in our study, suggesting that an independent relationship cannot be totally precluded.

It seems difficult and less worthwhile to establish an independent association between the two distinct physical phenomena. However, it is valuable when resting heart rate is considered as an indicator for risk assessment and stratification. Resting heart rate has long been neglected by physicians. The predicted value of resting heart rate was extensively tested in 2 large well-designed prospective studies\textsuperscript{[25]}. In the 2007 European Society of Hypertension-European Society of Cardiology guidelines\textsuperscript{[25]}, measurement of heart rate was recommended as an important component of cardiovascular disease assessment. The measurement of heart rate was used in screening and assessment of dyslipidemia in this study.

Several limitations to our study have to be mentioned. First, the relationship between cause and effect was not established due to the nature of cross-sectional design. Second, the subjects included in this study were middle aged and elderly Chinese free from cardiovascular diseases. Third, the heart rate of subjects, measured in epidemiological investigation fields other than in the office and at home, were influenced by the ‘white coat effect’\textsuperscript{[26]}. The resting heart rate measured at home and the office tends to be more stable and accurate, however, the measurements in epidemiological investigation can provide an equivalent predictive value\textsuperscript{[27]}.

In conclusion, subjects with elevated resting heart rate are at a greater risk of dyslipidemia, especially for high TG and TC. Resting heart rate can be regarded as a powerful indicator for dyslipidemia screening and risk assessment.

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Resting heart rate and dyslipidemia


