Hematocrit Correlates with Blood Pressure in Young Male Office Workers

Noriko NISHIKIDO*, Toshio KOBAYASHI and Hiroshi KASHIWAZAKI

*Community Health Nursing, St. Luke’s College of Nursing, 10–1 Akashi-cho, Chuo-ku, Tokyo 104-0044, Japan
2 Department of Hygiene and Preventive Medicine, School of Medicine, Fukushima Medical University, 1 Hikarigaoka, Fukushima-shi, Fukushima 960-1295, Japan
3 Department of Human Sciences, School of Health Sciences, University of Occupational and Environmental Health, 1–1 Iseigaoka, Yawatanishi-ku, Kitakyushu-shi, Fukuoka 807-8555, Japan

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Abstract: High hematocrit (Ht) level has been reported to be a correlating factor of hypertension in aged people, but has not been examined in younger generation. To investigate the association between Ht and blood pressure (BP) in healthy young workers, statistical analysis was performed for 646 male employees, using cross-sectional health-check data. Ht was positively correlated with systolic blood pressure (SBP) and with diastolic blood pressure (DBP) by Pearson’s simple correlation analysis. Multiple regression analysis for SBP and DBP was conducted by stepwise procedure, using Ht, age, body mass index (BMI), and drinking and smoking habits as independent variables. It was revealed that Ht was a significant independent variable for DBP (p<0.001), as well as age and BMI, but not for SBP. These findings suggest that increased Ht is an important variable for assessing risk for cardiovascular disorders, especially diastolic hypertension, in young male office workers.

Key words: Hematocrit, Blood pressure, Hypertension, Cardiovascular risk factors, Young office workers

Introduction

High hematocrit (Ht) level has been reported to be a risk factor of hypertension1-3), coronary heart disease (CHD)4-6), myocardial infarction7), and angina on effort8). However, physiological mechanisms for these relations have not been fully clarified. In several other studies, however, no significant relations have been found between Ht (or hemoglobin (Hb)) and blood pressure (BP)9-12), nor between Ht and cardiovascular diseases1,13-15).

The reasons for these controversial results are unknown, but differences in the types of subjects seem to be involved. Goubali et al. found significant positive correlation of Ht values with CHD and hypertension in women of the population sample but not in men of the population and occupational samples8). While most of the previous findings have been derived mainly from middle-aged or elderly subjects attending hypertension clinics, or from community-based population studies, very few epidemiological studies in the occupational health field have been carried out, especially on healthy young workers. With respect to the onset and procedure of stress-induced cardiovascular disorders, including hypertension, more information is needed in regard to healthy young workers. Recently, the impact of job stress on hypertension16-20) and CHD21) has been investigated by several researchers, but Ht has not been monitored in these studies. Therefore, in this study we examined whether Ht has a positive and significant association with blood pressure in young office workers, independently of other known risk factors for BP, such as age, obesity, smoking and drinking habits.

*To whom correspondence should be addressed.
Methods

Subjects

This study is based on data from a health examination performed in the spring of 1992. A total of 646 young male workers (age range: 18–41 years, mean ± SD: 28.3 ± 5.6) of a data-processing company located in the center of Tokyo, Japan, comprised the subjects of this study. Most of the subjects were engaged in system engineering and programming for computers. A few male workers under antihypertensive medication (n=3) and with serious anemia (n=1) were excluded from the analysis. All female workers were also excluded because of the small sample size (less than fifty).

Measurements

Blood pressure (BP) was measured using a mercury sphygmomanometer with a standard cuff, which was applied to the left upper arm of a seated subject. After 3 minutes rest in a sitting position, the first and fifth Korotkoff sounds were recorded as the systolic and diastolic blood pressure (SBP and DBP), respectively. In case the systolic measurement was ≥140 mmHg or the diastolic measurement was ≥ 90 mmHg, the measurement was repeated after a few minutes rest. The subjects were classified into three groups by BP according to the definition of WHO (1978), i.e., normotensives (SBP ≤ 140 mmHg and DBP ≤ 90 mmHg), borderline-hypertensives (140 mmHg<SBP<160 mmHg or 90 mmHg<DBP<95 mmHg), and hypertensives (SBP ≥ 160 mmHg or DBP ≥ 95 mmHg). For obesity the body mass index (BMI) was used: weight (kg)/height (m)2. Blood samples were obtained from the antecubital vein. Ht was computed by autoanalyzer (TOA E-4000, Tokyo) as the product of erythrocyte count and mean corpuscular volume. Each day the counter was calibrated by random repeated testing of standard samples. The coefficients of variation (interassay) of Ht were less than 2%.

Information on smoking and drinking habits was obtained by questionnaire conducted at the health check. Smoking habit was inquired by the following two questions: 1) Do you smoke or not? (smoking-habit), 2) Do you smoke 20 cigarettes a day or more? (smoking-amount). Drinking habit was inquired by the following three questions: 1) Do you drink at least once a week? (drinking-habit), 2) Do you drink 5 days a week or more? (drinking-frequency), 3) Do you drink 52 g alcohol (equivalent to 0.36 L of Japanese sake) a day or more? (drinking-amount). The answers to these questions were translated into dummy variables; “1” was given to “yes”, and “0” to “no”.

Analysis

One-way analysis of variance (ANOVA) was used to examine the significant variances of the variables among BP and age groups. Multiple range test was performed for comparing the significance of mean differences between groups when the ANOVA result was significant. Pearson's correlation coefficients were calculated between BP and the other variables. Stepwise multiple regression analysis was performed to examine the independent associations of Ht, age, BMI, smoking and drinking habits with SBP, DBP or pulse pressure (PP).

Results

Table 1 shows the ranges, means and standard deviations (SD) of age, blood pressures, body mass index and hematocrit in the subjects, and their smoking and drinking habits.

<table>
<thead>
<tr>
<th>variables</th>
<th>range</th>
<th>mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>18 – 41</td>
<td>28.3 (5.6)</td>
</tr>
<tr>
<td>systolic blood pressure</td>
<td>84 – 198</td>
<td>120.1 (13.6)</td>
</tr>
<tr>
<td>diastolic blood pressure</td>
<td>46 – 116</td>
<td>72.1 (10.7)</td>
</tr>
<tr>
<td>pulse pressure</td>
<td>20 – 96</td>
<td>48.0 (11.7)</td>
</tr>
<tr>
<td>body mass index</td>
<td>15.7 – 36.0</td>
<td>22.6 (3.2)</td>
</tr>
<tr>
<td>hematocrit</td>
<td>40.7 – 58.0</td>
<td>47.7 (2.7)</td>
</tr>
<tr>
<td>smoking-habit (#1)</td>
<td></td>
<td>53.4%</td>
</tr>
<tr>
<td>smoking-amount (#2)</td>
<td></td>
<td>39.9%</td>
</tr>
<tr>
<td>drinking-habit (#3)</td>
<td></td>
<td>83.7%</td>
</tr>
<tr>
<td>drinking-frequency (#4)</td>
<td></td>
<td>25.4%</td>
</tr>
<tr>
<td>drinking-amount (#5)</td>
<td></td>
<td>39.9%</td>
</tr>
</tbody>
</table>

(n=646)

#1 smoke or not (% of ‘yes’). #2 smoke 20 cigarettes a day or more. #3 drink or not. #4 drink 5 days a week or more. #5 drink 52 g alcohol a day or more.

Table 1. Ranges, means and standard deviations (SD) of age, blood pressures, body mass index and hematocrit in the subjects, and their smoking and drinking habits.
normotensive, borderline-hypertensive and hypertensive groups. As well as BP levels, age, BMI and Ht differed significantly by groups classified according to BP (by ANOVA, \( p<0.05 \)). Mean values of Ht or BMI in borderline-hypertensive and hypertensive groups were significantly higher than that in normotensive group (by Duncan’s multiple range test, \( p<0.01 \)), but there was no significant difference in Ht or BMI between borderline-hypertensive and hypertensive groups (\( p>0.05 \)). Mean age in the hypertensive group was significantly higher than that of the normotensive group (\( p<0.01 \)).

Table 4 shows the correlation coefficients of SBP, DBP and PP with age, BMI and Ht. Hematocrit, as well as age and BMI, showed significant simple correlations with SBP, DBP and PP (\( p<0.05 \)).

To examine the significant association between blood pressures and smoking or drinking habits, the mean values of SBP, DBP and PP in the groups with and without those habits were compared by t-test. Among the drinking and smoking habits, only drinking-frequency was positively associated with SBP and DBP (\( p<0.05 \) and \( p<0.001 \), respectively, data not shown).

Table 5 shows the results of stepwise multiple regression analysis: blood pressures (SBP, DBP, PP) as dependent variables, and BMI, age, Ht, and drinking-frequency as independent variables. BMI was selected as the significant independent variable to explain 13.3% of variance on SBP. BMI, age and Ht were selected as the significant variables on DBP, explaining 13.4, 8.2, and 3.8% of variances, suggesting that the increases of BMI, age and Ht were independently associated with the increase of DBP, respectively. As significant variables on PP, age, BMI and
Ht were selected, but these variables together explained only 5.7% of the variance. Drinking-frequency (i.e., drinking 5 days a week or more) was selected as the independent variable for SBP and DBP, but it explained only 1.0% of SBP and 0.8% of DBP variances.

**Discussion**

**Relation between HT and BP**

In the present study, Ht was positively correlated with both SBP and DBP by simple correlation analysis in young office workers. Multiple regression analysis, moreover, revealed that the association of Ht with DBP was significant and independent of several confounders, such as age, BMI and drinking habits, although Ht explained less variation of DBP than BMI and age. However, the association of Ht with SBP was not significant after removing the effect of other confounders.

Our results are similar to those of some previous studies. McDonough et al. showed significant partial correlation between Ht and DBP, but not between Ht and SBP, controlling for age in the African-American and white populations of Evans county (15–74 yr). Simone et al. examined relating factors for whole blood viscosity (WBV) in 128 representatives of normotensive members of a large employed population in New York City aged 27–75 yr. They found that DBP was an independent predictor of WBV and Ht levels but SBP was not, after removing the effects of age, race and BMI by partial correlation analysis. Our finding is important in that the same independent relation of Ht with DBP was observed in younger healthy workers.

As for the relation of Ht to SBP, Cirillo et al. reported that Ht was associated with both SBP and DBP independently of several confounders, such as age, BMI, pulse rate, etc. in 2809 men and women aged 25–74 yr. The relation of Ht with SBP is likely to be less visible than that with DBP, unless additional confounding factors, such as pulse rate, are controlled, probably because SBP seems to be more susceptible to transient mental stress. It should also be noted that there were several reports in which Ht was not significantly associated with either SBP or DBP. One of the possible reasons for the different findings is variance of the subjects in terms of age, gender, ethnic background and health conditions (especially BP level). Another possible reason is the degree of adjustment of confounding factors performed for BP, such as of age and BMI.

Concerning the use of Hb level instead of Ht, no significant difference in BP was reported between two groups of women (mean age 49 yr.) divided by the Hb level (Hb ≥ 10.5 vs. Hb<10.5). It was also reported that Hb levels were not correlated with BP variables in either sex of a large study population (25–64 yr.). Hb value may have different meaning from Ht value at least in the relation to BP variables.

<table>
<thead>
<tr>
<th>dependent variables</th>
<th>independent variables</th>
<th>standardized coefficients</th>
<th>R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>systolic blood pressure</td>
<td>body mass index</td>
<td>0.364***</td>
<td>0.133</td>
</tr>
<tr>
<td></td>
<td>age</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hematocrit</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drinking-frequency</td>
<td>0.099**</td>
<td>0.010</td>
</tr>
<tr>
<td>diastolic blood pressure</td>
<td>body mass index</td>
<td>0.290***</td>
<td>0.134</td>
</tr>
<tr>
<td></td>
<td>age</td>
<td>0.249***</td>
<td>0.082</td>
</tr>
<tr>
<td></td>
<td>hematocrit</td>
<td>0.193***</td>
<td>0.038</td>
</tr>
<tr>
<td></td>
<td>drinking-frequency</td>
<td>0.094*</td>
<td>0.008</td>
</tr>
<tr>
<td>pulse pressure</td>
<td>age</td>
<td>-0.191***</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>body mass index</td>
<td>0.140***</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td>hematocrit</td>
<td>-0.118**</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>drinking-frequency</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Standardized partial regression coefficients of stepwise multiple regression analysis for blood pressure

Body mass index, age, hematocrit, and drinking-frequency were applied as independent variables in stepwise regression analysis for blood pressure. #1: standardized partial regression coefficient *p<0.05, **p<0.01, ***p<0.001. #2: drink 5 days a week or more ('yes'=1, 'no'=0). NS: not significant.
Relation between HT and CHD

Several epidemiological studies have indicated that a higher Ht level was associated with CHD mortality and morbidity. Recently, it has been reported that moderately high Ht and Hb values are risk factors for the occurrence of myocardial infarction in male company workers (aged 50 to 60 years) by case-control retrospective study. One case of a taxi driver, in which the correlation between increased Ht and angina on effort was indicated, has also been reported in Japan, suggesting that these conditions might be associated with cumulative stress from repeated night work. In a study in Puerto Rico, Ht was found to be a significant variable in multiple logistic function analysis for CHD morbidity and mortality. In a Honolulu study, however, the relation between Ht and the specified manifestations of CHD was no longer significant after adjustment for other correlated variables. This discrepancy was possibly due to the difference in analytical methods, i.e., in the Honolulu study, DBP was added as an independent variable, concomitantly with Ht, for multivariate logistic regression analysis for CHD morbidity and mortality, while in the Puerto Rico study SBP was added instead of DBP to the regression model. Because DBP relates more strongly with Ht than SBP in both studies, it seems reasonable that the observed influence of Ht for the manifestations of CHD might have been masked by the inclusion of DBP within the regression model.

Possible mechanisms

Concerning the relation between Ht and BP, or between Ht and cardiovascular diseases, several possible mechanisms have been suggested. Tarazi et al. and Dustan et al. described that plasma volume was inversely related to DBP in hypertensives. Emery et al. and Chrysant et al. reported that so-called stress polycythemia can be reversed by antihypertensive therapy, suggesting that elevated arterial pressure might be related to contracted plasma volume in peripheral veins through increased transcapillary filtration of plasma, which resulted in increased Ht level. However, Cirillo et al. discussed that an increase in blood pressure is unlikely to be followed by an increase in Ht. According to their data, the mean Ht of a drug-treated hypertensive group was as high as that of an untreated hypertensive group, even though the mean blood pressure was much lower in the former.

Other explanations for the relationship between hypertension and increased Ht level include hyperviscosity of whole blood. It has been proposed that with treatment of anemia, increased Ht was followed by increased blood viscosity together with a rise of blood pressure. These observations suggest that Ht clearly represents the main determinant for whole blood viscosity (WBV), and thus increased Ht means elevated peripheral resistance to blood flow. The causal relationship of Ht and high blood pressure, especially DBP, needs further studies.

In conclusion, this study demonstrated an independent relation between Ht and DBP in healthy young office workers. Redirecting our focus on this point will be particularly important in the occupational health field; less attention has been paid to increased Ht than to decreased Ht, which has been receiving great attention as a good indicator of anemia. Recently, several researchers investigated the relationship between work-related mental stress and BP and CHD. Hayashi reported that overtime work was associated with BP increase. Further studies on the relationship between work-related stress and manifestations of cardiovascular disorders, as well as risk factors for them, are urgently required. Ht-monitoring in workers would be one of the essential steps for investigating the mechanisms of such stress-induced alterations in the cardiovascular system. Longitudinal cohort studies will be necessary to clarify the causal relations among Ht, BP, cardiovascular diseases and work-related stress in workers. It must be emphasized that the independent relation of Ht with DBP existed even in the cross-sectional data of healthy young office workers in Japan.

References

6) Goubali A, Voukiklaris G, Kritsikis Sp, Viliotou F,


