SEX-SPECIFIC ANALYSIS OF LEFT VENTRICULAR GEOMETRY IN A POPULATION STUDY IN TALLINN

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Summary

Objectives: The aim of this study was to determine the association of the left ventricular geometry (LVG) with gender, arterial hypertension and obesity in Tallinn citizens.

Design and Methods: In a framework of the population study for cardiovascular risk factors echocardiography was carried out in 325 men and 398 women (69.3% of all 1043 participants aged between 35–59 years) during 1999–2001. Left ventricular hypertrophy was defined if left ventricular mass (LVM), LVM/height and LVM to body surface area (BSA) ratio (LVM/BSA) exceeded 294 g, 163 g/m, 150 g/m² in men, and 198 g, 121 g/m, 120 g/m² in women, respectively. LVG was analyzed according to the generally recognized four types (with regard to relative wall thickness >0.45), described below.

Results: The prevalence of concentric hypertrophy was similar in men and women: 7.7% and 9.1%, respectively. The prevalence of eccentric hypertrophy was significantly higher in women than in men (33.3% vs 4.9%). Concentric remodelling was also found in women more often than in men (9.5 vs 5.5%, p<0.05).

Regardless of gender, concentric hypertrophy was never found in participants with blood pressure (BP) <140/90 mm Hg. In hypertensives concentric hypertrophy was higher in women than in men: 39.1% vs 25.5%, p<0.05. This type of LVG was rarely found in persons with body mass index <30 kg/m²: in 3.1% of men and 5.0% of women; p<0.05. In obese persons it reached 26.5% in men and 21.2% in women (p<0.05).

Conclusions: The prevalence of eccentric hypertrophy in men increased with hypertension and obesity. The prevalence of concentric remodelling in men was not related to body mass index; it was significantly more often found in hypertensives. In women, the prevalence of eccentric hypertrophy and concentric remodelling was not related to hypertension and obesity.

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Along with generally known risk factors for cardiovascular disease (arterial hypertension, elevated cholesterol, smoking, obesity) the problem of the left ventricular hypertrophy (LVH), nowadays connected with extremely unfavourable prognosis, attracts the attention of cardiologists [1–6]. However, the prevalence and prognostic value of LVH vary among nationalities and populations [2,7,8]. In the framework of epidemiologic studies for cardiovascular risk factors carried out in Estonia, different left ventricular (LV) geometric patterns have not been analysed. Also, the significance of LV mass changes has not been evaluated separately in men and women.

The aim of this study was to determine the prevalence of LVH in a middle-aged population in Tallinn (Estonia), to assess the relation between LVH and gender, blood pressure (BP), and body mass index (BMI).

Design and Methods

A random sample of the population of Tallinn, capital of Estonia, 1043 men and women aged between 35–59 years, were included into the study. The sample was formed on the base of the Estonian Population Register with response rate of 64%. The study was performed in a framework of the cardiovascular and noncommunicable disease risk factors survey carried out for the WHO/CINDI Programme between 1999–2001. The investigation was conformed with the principles outlined in the Declaration
of Helsinki and approved by the local ethics committee. The population was investigated using standard epidemiological methods: weight was measured in the participants without shoes and heavy outer garments and rounded to the nearest 100 g; height was rounded to the nearest 0.5 cm. Body mass index (weight (kg)/height (m)^2) was calculated, and obesity was defined if BMI ≥ 30 kg/m^2. 325 men and 398 women underwent echocardiography (Echo). Patients with valvular pathology and primary cardiomyopathy were excluded.

Three BP measurements were performed in each participant. Investigators of the Department of Preventive Cardiology performed two measurements at the screening, the second reading being taken 2 minutes later. The third measurement was taken at the Department of Clinical Cardiology by cardiologist 2–7 days after the screening before Echo. BP was recorded in an office in the sitting position after 5–10 min rest using a mercury sphygmomanometer and rounded to the nearest 2 mm Hg. Diastolic BP was determined according to the fifth Korotkoff phase. An examinee was classified as hypertensive if mean values of two BP measurements at the screening and the third measurement before Echo exceeded 140/90 mm Hg. 27.4% of hypertensives received antihypertensive therapy regularly, but only 8.0% of them had their BP < 140/90 mm Hg.

Our echocardiographic procedure has been described in detail previously [9]. Left ventricular posterior wall thickness (PWTd), ventricular septal thickness (LVSTd), and LV internal dimension (LVd) at the end diastolic phase were measured according to the Penn conventions. Relative wall thickness (RWT) was calculated as follows: RWT = 2 × PWT/LVd (RWT < 0.45 was considered normal). LV mass was deduced from the following formula:

\[
LV mass (g) = 1.04 \times \left[(LVd + PWTd + LVSTd)^3 - (LVd)^3\right] - 13.6.
\]

Three indexes were used as diagnostic criteria of LVH: left ventricular mass (g), left ventricular mass (g)/height (m), left ventricular mass (g)/body surface area (BSA) (m^2). Gender-specific LVH criteria according to the Framingham Heart study [10] were 294 g, 163 g/m, 150 g/m^2 for men and 198 g, 121 g/m, 120 g/m^2 for women, respectively. LVH was defined if at least two of these parameters were increased.

LV geometry was classified into the following four types: concentric hypertrophy (increased LV mass and RWT); eccentric hypertrophy (increased LV mass and normal RWT); concentric remodelling (normal LV mass and increased RWT); normal geometry (normal LV mass and normal RWT).

Data were presented as mean ± standard deviation. Differences were tested by the Student's test and \( \chi^2 \) test when appropriate. The strength of the relation between some clinical and echocardiographic variables was assessed by the Pearson correlation coefficient. Calculations were performed on a computer with SPSS software. In two-tailed tests, \( p \) values < 0.05 were considered statistically significant.

**Results**

Men had a higher occurrence of arterial hypertension (30.2% compared with 23.1% of women, \( p < 0.05 \)). The incidence of obesity was similar in both sexes: BMI > 30 kg/m^2 was found in 19.7% of men and 24.9% of women.

The prevalence of echocardiographic LVH and LV geometric patterns is presented in Figure 1. The

**Figure 1.** The prevalence of left ventricular geometric patterns in men and women (%). CH – concentric hypertrophy; CR – concentric remodelling; EH – eccentric hypertrophy; NG – normal geometry

* *difference between men and women \( p < 0.05 \)
Concentric hypertrophy significantly increased in hypertensive men and women (44.9% vs 23.9%, vs 54.6%,
and just over half of women with normal BP (97.8% only. Normal geometry was revealed in most men significantly more often found in hypertensive men with BP ≥ 140/90 mm Hg. Eccentric hypertrophy; NG – normal geometry

Table 1. Left ventricular geometric patterns in men and women in relation to blood pressure

<table>
<thead>
<tr>
<th>BP (mm Hg)</th>
<th>Prevalence of left ventricular geometric patterns (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
</tr>
<tr>
<td></td>
<td>n CH EH CR NG</td>
</tr>
<tr>
<td>&lt;140/90</td>
<td>227 0.9 1.3 97.8</td>
</tr>
<tr>
<td>&gt;140/90</td>
<td>98 25.5 14.3 15.3 44.9 92 39.1 29.4 7.6 23.9</td>
</tr>
</tbody>
</table>

* difference between men and women with the same blood pressure, p < 0.05
BP – blood pressure; CH – concentric hypertrophy; CR – concentric remodelling; EH – eccentric hypertrophy; NG – normal geometry

Table 2. Left ventricular geometric patterns in men and women in relation to body mass index

<table>
<thead>
<tr>
<th>BMI (kg/m²)</th>
<th>Prevalence of left ventricular geometric patterns (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
</tr>
<tr>
<td></td>
<td>n CH EH CR NG</td>
</tr>
<tr>
<td>&lt; 30</td>
<td>261 3.1 3.1 5.3 88.5</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>64 26.5 12.5 6.3 54.7</td>
</tr>
</tbody>
</table>

* difference between men and women with the same blood pressure, p < 0.05
BMI – body mass index; BP – blood pressure; CH – concentric hypertrophy; CR – concentric remodelling; EH – eccentric hypertrophy; NG – normal geometry

prevalence of concentric hypertrophy was similar in men and women. The prevalence of eccentric hypertrophy in women was six–seven-fold in comparison with men. Concentric remodelling was slightly greater in women than in men. On the contrary, the prevalence of normal geometry was lower in women than in men.

The prevalence of LVH and LV geometric patterns in participants with normal BP and BP ≥ 140/90 mm Hg is illustrated in Table 1. It turned out that concentric hypertrophy was never found in examiners with normal BP regardless of gender. In hypertensives concentric hypertrophy was higher in women than in men: 39.1% vs 25.5%, p < 0.05. The prevalence of eccentric hypertrophy was very rare in men with BP < 140/90 mm Hg (0.9%) and increased up to 14.3% in men with BP > 140/90 mm Hg. Concentric hypertrophy was found in about one-third of normotensive and hypertensive women. Concentric remodelling was found rarely in men and women with normal BP (1.3% vs 10.1%, p < 0.05). It was significantly more often found in hypertensive men only. Normal geometry was revealed in most men and just over half of women with normal BP (97.8% vs 54.6%, p < 0.05). It was obtained more rarely in hypertensive men and women (44.9% vs 23.9%, p < 0.05).

As it is shown in Table 2, the prevalence of concentric hypertrophy is low in non-obese participants. Concentric hypertrophy significantly increased in obese persons of both genders and was higher in men than in women (26.5% vs 21.2%, p < 0.05). No significant differences concerning the prevalence of eccentric hypertrophy were found in women with different BMI. However, the prevalence of eccentric hypertrophy was higher in men with BMI > 30 kg/m² than in men with BMI < 30 kg/m². The prevalence of concentric remodelling was twice higher in women with BMI < 30 kg/m² than in men (10.7% vs 5.3%, p < 0.05), and was similar in obese persons (6.1% vs 6.3%, respectively).

The linear correlation between LV mass (non-indexed and indexed) and some clinical data were examined within both genders (Table 3). The strongest correlation coefficient between systolic, diastolic and mean blood pressures, and the three LV mass indexes in both genders was obtained. These indexes were higher in women than in men. For the weight the correlation was more scattered; adjustment to BSA decreased the values of correlation coefficients in both genders. It seemed interesting to us that one of the lowest correlation coefficients was observed between the heart rate (beats/min) and all LV mass parameters, nevertheless it was positive in men but negative in women.

Discussion
A number of studies demonstrated that BMI and systolic BP had a strong synergistic association with LVH in men, but not in women [11–14]. Our obser-
The prevalence of eccentric hypertrophy was ten-fold in normotensive women compared to men and two-fold in hypertensive women than in hypertensive men. Concentric remodelling was found significantly more often in hypertensive men. Several studies described that hypertensive patients had a high prevalence of LVH, especially eccentric hypertrophy [11,15,16]. For example, from the general Danish population of 3498 men and women aged between 35–65 years [16], the prevalence of LVH was 14%/20% (men/women) in normotensives and 25%/26% in hypertensives, however the difference between normotensives and hypertensives was significant in age groups of 65 years. Authors considered that association between BP and LVH in a general population was weak and only LVH was significantly more frequent among elderly hypertensives as compared to normotensives. Hessen et al [17] mentioned that gender differences in LV geometry in hypertensives were presented only with the Framingham, though not with the Koren criteria. Some differences in the results may be related to the methodological variations because there is a lack of consensus on the mode of indexation of LVM (BSA, height, height$^2$) and on the cut-off values for definition of LVH. Coca et al [11] reported that the prevalence of LVH was higher in males according to the Cornell–Penn criteria, but higher in females according to the Framingham criteria, eccentric hypertrophy was more frequent independently of the criteria used. In that respect, our data coincide with those of Coca et al.

It has been established that obesity puts a strain on both hemodynamics and metabolism of heart. Wirth et al [18] noted that LVH occurred twelve times more often among obese than among slim persons. According to our data, the prevalence of concentric hypertrophy was rarely found in males and females with BMI $< 30$ kg/m$^2$. It was increased in obese persons of both genders. The prevalence of eccentric hypertrophy was rarely found in men with BMI $< 30$ kg/m$^2$ as well, but it was significantly higher in obese men. The prevalence of eccentric hypertrophy was found in about one-third of women regardless of BMI. Concentric remodelling did not relate with BMI in both genders. The correlation coefficient obtained between weight or BMI and LV mass/BSA was low in men as well as in women. It could be debated that before the onset of hypertension, the increased LV mass appears to have different determinants in men and women. Marcus et al [19] suggested that early LVH in young men was a manifestation of hyperkinetic borderline hypertension, a state, previously shown to be associated with the increased sympathetic nervous system activity and insulin resistance. The hyperkinetic state is less prevalent in young women, in whom increased adiposity seems to be the predominant factor associated with LVH. On the contrary, according to the opinion of Saba et al [20], left ventricular mass index (LVMI) was weakly inversely related to the heart rate in males and females in total. RWT was positively associated with the heart rate in hypertensive females, and an elevated resting heart rate occurred to be associated with abnormal left ventricular geometry (LVG), namely, concentric remodelling and hypertrophy. No such relationship was found in males.

### Table 3. Linear correlation between left ventricular mass parameters and some clinical data

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Correlation coefficient ($r$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LVM</td>
</tr>
<tr>
<td>Age (years)</td>
<td>Men</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.126</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>0.46</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>0.163</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>0.426</td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>0.327</td>
</tr>
<tr>
<td>Mean BP</td>
<td>0.256</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>0.311</td>
</tr>
</tbody>
</table>

BP – blood pressure; BMI – body mass index; BSA – body surface area; LVM – left ventricular mass
Our findings have shown that the prevalence of concentric and eccentric hypertrophy increased in connection with hypertension and obesity in men only. The prevalence of concentric hypertrophy was associated with hypertension and obesity in women as well. Our data demonstrated relatively high frequency of eccentric hypertrophy in women, which was not obviously related to hypertension and BMI. Probably, despite of hypertension and obesity in women, several endocrine factors and lipid disorders should be also taken into account. The Framingham Study [21] has demonstrated that less than 20% of hypertension occurs in isolation of other risk factors, usually it occurs in conjunction with other metabolically linked risk factors. In the recent study by Sundstrom et al [22] it has been shown that dyslipidemia, as well as hypertension and obesity, at 50 years of age, predicts the prevalence of LVH 20 years later, thereby suggesting that lipids may be important in the origin of LVH. Gender-specific analyses of plasma lipids or glucose, and cigarette smoking have not been performed in our study. It has just seemed to us that the high prevalence of concentric and eccentric hypertrophy in women emerges as a potentially important and under-recognized factor of their cardiovascular risk.

Conclusions

In the present study we have observed that 81.9% of the middle-aged men and only 47.5% of women has normal left ventricular geometry. On the other hand, 12.6% of men and 43% of women has signs of left ventricular hypertrophy. Eccentric hypertrophy is predominant. In the most of the patients left ventricular hypertrophy has been found for the first time. Our results suggest that the frequency of normal left ventricular geometry decreases in both genders, when hypertension and obesity are prevalent. Concentric hypertrophy is associated with elevated blood pressure and obesity in both genders. Eccentric hypertrophy and concentric remodelling are not related to hypertension and obesity in men only. The prevalence of eccentric hypertrophy in men increases with hypertension and obesity. The prevalence of concentric remodelling in men is not related to body mass index; it is significantly more often found in hypertensives.

Acknowledgements

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References


