Association of Socioeconomic Status in Childhood With Left Ventricular Structure and Diastolic Function in Adulthood

The Cardiovascular Risk in Young Finns Study

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IMPORTANCE Increased left ventricular (LV) mass and diastolic dysfunction are associated with cardiovascular disease. Prospective data on effects of childhood socioeconomic status (SES) on measures of LV structure and function are lacking.

OBJECTIVE To examine whether family SES in childhood was associated with LV mass and diastolic function after adjustment for conventional cardiovascular disease risk factors in childhood and adulthood.

DESIGN, SETTING, AND PARTICIPANTS The analyses were performed in 2016 using data gathered in 1980 and 2011 within the longitudinal population-based Cardiovascular Risk in Young Finns Study. The sample comprised 1871 participants who reported family SES at ages 3 to 18 years and were evaluated for LV structure and function 31 years later.

EXPOSURES Socioeconomic status was characterized as annual income of the family and SES at ages 3 to 18 years.

MAIN OUTCOMES AND MEASURES Left ventricular mass indexed according to height at the allometric power of 2.7 and the E/e’ ratio describing LV diastolic performance at ages 34 to 49 years.

RESULTS The participants were aged 3 to 18 years at baseline (mean [SD], 10.8 [5.0] years), and the length of follow-up was 31 years. Family SES was inversely associated with LV mass (mean [SD] LV mass index, 31.8 [6.7], 31.0 [6.6], and 30.1 [6.4] g/m² in the low, medium, and high SES groups, respectively; differences [95% CI], 1.7 [0.6 to 2.8] for low vs high SES; 0.8 [−0.3 to 1.9] for low vs medium; and 0.9 [0.1 to 1.6] for medium vs high; overall P = .001) and E/e’ ratio (mean [SD] E/e’ ratio, 5.0 [1.0], 4.9 [1.0], and 4.7 [1.0] in the low, medium, and high SES groups, respectively; differences [95% CI], 0.3 [0.1 to 0.4] for low vs high SES; 0.1 [−0.1 to 0.3] for low vs medium; and 0.2 [0 to 0.3] for medium vs high; overall P < .001) in adulthood. After adjustment for age, sex, and conventional cardiovascular disease risk factors in childhood and adulthood, and participants’ own SES in adulthood, the relationship with LV mass (differences [95% CI], 1.5 [0.2 to 2.8] for low vs high SES; 1.3 [0 to 2.6] for low vs medium; and 0.2 [−0.6 to 1.0] for medium vs high; P = .03) and E/e’ ratio (differences [95% CI], 0.2 [0 to 0.5] for low vs high SES; 0.1 [−0.1 to 0.4] for low vs medium; and 0.1 [0 to 0.3] for medium vs high; P = .02) remained significant.

CONCLUSIONS AND RELEVANCE Low family SES was associated with increased LV mass and impaired diastolic performance more than 3 decades later. These findings emphasize that approaches of cardiovascular disease prevention must be directed also to the family environment of the developing child.

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Socioeconomic inequalities in cardiovascular disease (CVD) present a major and persistent public health challenge across industrialized nations. Socioeconomic status (SES) is a powerful predictor of incident coronary disease and adverse cardiovascular outcomes. Whether this robust association with SES extends to heart failure (HF) is less certain, as approximately half of cases relate to coronary disease.

Echocardiographically measured left ventricular (LV) mass is associated with incident HF not related to myocardial infarction. Left ventricular diastolic dysfunction is also prognostic of incident HF. Previous studies have shown that low educational attainment in middle or older age is associated with higher LV mass and impaired LV diastolic function. Occupational status at different stages of life course is associated with LV mass and diastolic function at age 60 to 64 years. However, to our knowledge, no studies have prospectively examined whether family SES in childhood, based on the annual income of the family, after adjustment for conventional CVD risk factors in childhood and adulthood, is associated with LV structure and diastolic function.

Using data from the longitudinal Cardiovascular Risk in Young Finns Study cohort, we examined the association of childhood family SES in participants aged 3 to 18 years on echo measures of LV mass and LV diastolic function 31 years later in adulthood when aged 34 to 49 years. We have previously shown that childhood risk factors are associated with subclinical CVD, eg, increased carotid intima-media thickness and coronary artery calcification, even when adjusted with adulthood risk factor levels. Therefore, we also performed analyses taking into account the effects of both childhood and adulthood risk factors.

Methods
Participants
The Cardiovascular Risk in Young Finns Study is an ongoing multicenter follow-up study to assess risk factors underlying CVD. The first cross-sectional survey was conducted in 1980, when 3596 individuals aged 3 to 18 years participated. These participants were randomly chosen from the national register of the study areas in different parts of Finland. Since 1980, several follow-up studies have been conducted. The 31-year follow-up survey was performed in 2011 and included analysis of 2063 of the original participants. Of these 2063 individuals, 1994 (96.7%) participated in the echocardiographic examination. In the present study, the sample comprised 1871 participants who were aged 3 to 18 years at baseline (ie, childhood in 1980) who provided data on family SES in childhood and echocardiographic data at follow-up (ie, adulthood in 2011), when aged 34 to 49 years. All participants provided written informed consent, and the study was approved by the Turku University Hospital ethical committee.

Family SES
Family annual income was considered an indicator of family SES. Parents of the participants reported the annual income of the family in childhood. The questionnaire included income categories from 1 (lowest) to 8 (highest). Family income in 1980 was converted into its present-day value and 3 income groups were formed: low (response options 1-2, SUS $14 600), medium (response options 3-5, SUS $14 600 to SUS 32 200), and high (response options 6-8, SUS 32 200). As sensitivity analysis, we additionally defined family SES according to parental occupation. Parental occupation was coded from 1 to 5 (1, indicating farmers; 2, lower manual; 3, upper manual; 4, lower nonmanual; and 5, upper nonmanual).

Cardiovascular Risk Factors
Height and weight were measured, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Blood pressure was measured using a random-zero sphygmomanometer. The average of 3 measurements of blood pressure was used in the analyses. For the determination of serum lipid levels, venous blood samples were drawn after an overnight fast both in childhood and adulthood. These analyses, as well as measurements of adulthood glucose levels, were performed with standard enzymatic methods. Information on smoking habits (participants' and participants' parents') was obtained with a questionnaire. Data on childhood smoking were collected in participants aged 12 to 18 years. In adulthood, a questionnaire was used to gather data on participants' SES (annual income). A questionnaire was also used to assess data on favorable emotional family environment and to subsequently comprise a score consisting of 4 components (absence of diagnosed parental mental disorder, high parental caregiving nurturance, high parental life satisfaction, and reasonable alcohol use). In the score, all components indicated 1 point; thus, the scale range was 0 to 4.

Echocardiography
Echocardiographic examinations were performed in adulthood according to American and European guidelines. Transthoracic echocardiograms were performed with Sequoia 512 (Acuson) ultrasonography, using a 3.5-MHz scanning frequency phased-array transducer. Analyses of the echo images were performed by a single observer. Both the sonographer and the observer were blinded to the participants' details. Standard echocardiographic examinations were produced from the standardized image planes and modes.

Key Points
Question Is childhood family socioeconomic status associated with left ventricular mass and diastolic function in adulthood?
Findings In this cohort study of 1871 participants, family socioeconomic status in childhood was related to left ventricular mass and diastolic function even after adjustment for age, sex, conventional cardiovascular risk factors both in childhood and adulthood, and participants’ own socioeconomic status in adulthood.

Meaning These data suggest that adverse childhood socioeconomic environment is associated with higher left ventricular mass and poorer diastolic function in middle age.
parasternal long and short axis in 2-dimensional and M-mode and apical 4-chamber view. Left ventricular mass in grams was calculated from these measurements, as follows: 0.8[1.04[(LV end-diastolic diameter + posterior wall thickness + septal wall thickness)² - LV end-diastolic diameter)] + 0.6.²⁷ Left ventricular mass was indexed according to height at the allometric power of 2.7 (indexed LV mass = LV mass/height²·⁷) because this indexation performs better in the context of overweight/obesity.²⁰ Transmirtal flow and tissue velocities were measured using continuous and pulsed-wave Doppler to define LV diastolic performance index, E/e' ratio, as previously described.¹⁷ In this study, most of the values of LV mass index and E/e' ratio are within the normal range²⁷ (Figure 1 and Figure 2).

**Statistical Analyses**

To examine the associations of childhood cardiovascular risk factors with childhood family SES, we used age- and sex-adjusted linear regression for continuous outcome variables and age- and sex-adjusted logistic regression for binary variables. Associations of family SES in childhood with cardiac structure and function in adulthood were examined using linear regression. Pairwise comparisons of the SES groups were adjusted with the Tukey-Kramer method. The analyses were performed both unadjusted and adjusted with age, sex, and conventional cardiovascular risk factors (BMI, systolic blood pressure, smoking, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, and triglycerides) in childhood and adulthood. To examine age and sex differences in the association of SES with LV mass and E/e' ratio, interaction terms of age-by-SES and sex-by-SES were used. No significant age or sex differences were detected indicating that the effect of SES on LV mass and E/e' ratio was similar between different age groups and between male and female participants. Thus, age groups and sexes were analyzed combined. All statistical tests were performed using SAS version 9.4 (SAS Institute) with statistical significance inferred at a 2-tailed P value < .05.
Table 1. Baseline Characteristics of the 1871 Cardiovascular Risk in Young Finns Study Participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Childhood Family SES, Mean (SD)*</th>
<th>P Value for Age- and Sex-Adjusted Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n = 262)</td>
<td>Medium (n = 779)</td>
</tr>
<tr>
<td>Age at baseline, y</td>
<td>11.7 (5.0)</td>
<td>10.5 (5.0)</td>
</tr>
<tr>
<td>Boys, No. (%)</td>
<td>115 (43.9)</td>
<td>362 (46.5)</td>
</tr>
<tr>
<td>Smokers, No. (%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42 (27.6)</td>
<td>76 (20.1)</td>
</tr>
<tr>
<td>Parental smoking, No. (%)</td>
<td>175 (79.2)</td>
<td>540 (74.3)</td>
</tr>
<tr>
<td>BMI</td>
<td>18.4 (3.3)</td>
<td>17.9 (3.1)</td>
</tr>
<tr>
<td>BP, mm Hg</td>
<td>112.5 (12.7)</td>
<td>112.5 (12.1)</td>
</tr>
<tr>
<td>Cholesterol, mg/dL</td>
<td>68.3 (10.0)</td>
<td>69.3 (9.3)</td>
</tr>
<tr>
<td>HDL</td>
<td>57.9 (11.58)</td>
<td>61.78 (11.58)</td>
</tr>
<tr>
<td>LDL</td>
<td>135.14 (30.89)</td>
<td>135.14 (34.75)</td>
</tr>
<tr>
<td>Triglycerides, mg/dL</td>
<td>61.95 (26.55)</td>
<td>61.95 (26.55)</td>
</tr>
<tr>
<td>Favorable emotional family environment score</td>
<td>2.6 (1.0)</td>
<td>2.5 (0.9)</td>
</tr>
</tbody>
</table>

Abbreviations: LV, left ventricular; SES, socioeconomic status.

* Low family SES indicates that the family annual income was <US $14,600; medium, US $14,600 to <US $32,200; and high, US $32,200.

Table 2. Association Between Family SES in Childhood With LV Mass 31 Years Later in Adulthood

<table>
<thead>
<tr>
<th>Family SES Model</th>
<th>LV Mass, g/m²&lt;sup&gt;2.7&lt;/sup&gt;</th>
<th>SES, Difference (95% CI)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SES&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Low</td>
</tr>
<tr>
<td>Unadjusted model, mean (SD) (n = 1845)</td>
<td>31.8 (6.7)</td>
<td>31.0 (6.6)</td>
</tr>
<tr>
<td>Adjusted model 1, mean (n = 1712)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>32.4</td>
<td>31.1</td>
</tr>
<tr>
<td>Adjusted model 2, mean (n = 1210)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>32.1</td>
<td>30.8</td>
</tr>
</tbody>
</table>

Abbreviations: LV, left ventricular; SES, socioeconomic status.

Table 3. Association Between Family SES in Childhood With Diastolic Function (E'/e' Ratio) 31 Years Later in Adulthood

<table>
<thead>
<tr>
<th>Family SES Model</th>
<th>E'/e' Ratio</th>
<th>SES, Difference (95% CI)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SES&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Low</td>
</tr>
<tr>
<td>Unadjusted model, mean (SD) (n = 1871)</td>
<td>5.0 (1.0)</td>
<td>4.9 (1.0)</td>
</tr>
<tr>
<td>Adjusted model 1, mean (n = 1733)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.9</td>
<td>4.8</td>
</tr>
<tr>
<td>Adjusted model 2, mean (n = 1223)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.9</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Abbreviation: SES, socioeconomic status.

* Low family SES indicates that the family annual income was <US $14,600; medium, US $14,600 to <US $32,200; and high, US $32,200.

High SES was associated with a lower risk of cardiovascular disease in young adulthood. The effect of family SES on E'/e' ratio was not statistically significant in participants aged 12 to 18 years (n = 593) when participants' own smoking status in childhood was added to the model (differences [95% CI], 0.3 [−0.1 to 0.6] for low vs high SES; 0.2 [−0.2 to 0.5] for low vs medium; and 0.1 [−0.1 to 0.3] for medium vs high; overall
The association of childhood lower family SES and adverse changes in cardiac structure and function. Other potential mechanisms may underlie the findings observed in this study. Previously it has been suggested that childhood SES and early family environment contribute to metabolic functioning through pathways of depression, hostility, and poor quality of social contacts. Adverse childhood experiences, including abuse, neglect, and household dysfunction, have also been associated with many health risk behaviors and diseases. A model introduced in 2012 suggests that positive psychological experiences may at the same time increase restorative processes (eg, healthy behaviors) and decrease deteriorative processes (eg, inflammation), leading to better cardiovascular health. We have previously reported that higher SES and positive psychosocial factors in childhood are associated with subsequent cardiovascular health, as defined by the American Heart Association. In this study, however, the association of family SES in childhood with adult LV mass and diastolic function was independent of the number of positive emotional factors in the childhood family.

Discussion

These prospective data suggest that adverse childhood socioeconomic environment is associated with higher LV mass and poorer diastolic function more than 3 decades after the baseline evaluation. Family SES in childhood, characterized on the basis of family annual income, was related to LV mass and diastolic function even after adjustment for age, sex, and conventional cardiovascular risk factors in childhood. Moreover, the inverse association of family SES with LV mass and diastolic function was independent of adulthood conventional cardiovascular risk factors and participants’ own SES in adulthood. Left ventricular hypertrophy is associated with CVD morbidity in adulthood. Of cardiovascular risk factors, childhood obesity is linked with eccentric LV hypertrophy in adulthood. Here, we observed that childhood family SES was associated with adult LV mass after adjustment for BMI and other conventional CVD risk factors measured both in childhood and adulthood. Moreover, the association was independent of participants’ own SES in adulthood. These results suggest that family SES in early life is an important determinant of subsequent LV mass.

Left ventricular diastolic function is recognized as an important marker of hemodynamic status. Here, we examined LV diastolic function by using the E/e’ ratio, where E wave in the pulsed Doppler registration describes the early mitral inflow in diastole, and e’ in the tissue Doppler registration measures the mitral annular longitudinal motion in early diastole. The E/e’ ratio is considered the best echocardiographic measurement of diastolic function in the estimation of LV filling pressure. In this study, we observed that children with lower family SES had poorer LV diastolic performance in adulthood. This finding is important because LV diastolic performance is associated with primary cardiac events and incident HF.

Socioeconomic deprivation is associated with HF development. The effect is only partly explained by established CVD risk factors measured in adulthood. To our knowledge, this study is the first that prospectively examined the association of childhood SES with subsequent cardiac structure and function also taking into account the role of childhood risk factors. This is important because differences in risk factor levels related to SES have been observed in the life course already in children and adolescents. However, even though we also found differences in several childhood CVD risk factors according to family SES, the association of family SES on adult measures of LV mass and diastolic function remained significant after adjustment of CVD risk factors measured both in childhood and adulthood. These findings suggest that differences in childhood CVD risk factors are not necessarily the principal pathway linking low childhood SES and adverse changes in cardiac structure and function.
associated with increased LV mass and poorer diastolic performance 3 decades later in adulthood. These findings further emphasize that approaches of CVD prevention must be directed also to the family environment of the developing child. Particularly, support for families with low SES may pay off in sustaining cardiovascular health to later life.

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**REFERENCES**


Association of Socioeconomic Status With Left Ventricular Structure

Origianal Investigation

Research


