

## Association of socioeconomic position with insulin resistance among children from Denmark, Estonia, and Portugal: cross sectional study

Debbie A Lawlor, Maarike Harro, Niels Wedderkopp, Lars Bo Andersen, Luis B Sardinha, Chris J Riddoch, Angie S Page, Sigmund A Anderssen, Karsten Froberg, David Stansbie, George Davey Smith

### Abstract

**Objectives** To examine the association between socioeconomic position and insulin resistance in children from three countries in northern Europe (Denmark), eastern Europe (Estonia), and southern Europe (Portugal) that have different physical, economic, and cultural environments.

**Design** Cross sectional study.

**Participants** 3189 randomly selected schoolchildren aged 9 and 15 years from Denmark (n = 933), Estonia (n = 1103), and Portugal (n = 1153).

**Main outcome measure** Insulin resistance (homoeostasis model assessment).

**Results** Family income and parental education were inversely associated with insulin resistance in Danish children but were positively associated with insulin resistance in Estonian and Portuguese children. Among Danish children, insulin resistance was 24% lower (95% confidence interval -38% to -10%) in those whose fathers had the most education compared with those with the least education. The equivalent results were 15% (2% to 28%) higher for Estonia and 19% (2% to 36%) higher for Portugal. These associations remained after adjustment for a range of covariates: -20% (-36% to -5%) for Denmark, 10% (-4% to 24%) for Estonia, and 18% (-1% to 31%) for Portugal. Strong statistical evidence supported differences between the associations in Denmark and those in the other two countries in both unadjusted and adjusted models (all  $P < 0.03$ ).

**Conclusions** Among Danish children, those with the most educated and highest earning parents had least insulin resistance, whereas the opposite was true for children from Estonia and Portugal.

### Introduction

Adverse childhood socioeconomic position is associated with increased risk of coronary heart disease in later life,<sup>1</sup> and this may, at least in part, be mediated by insulin resistance.<sup>2</sup> Socioeconomic inequalities in health outcomes are dynamic and vary over time and between countries.<sup>3</sup> Differences between countries can provide useful insights into the causes of health

inequalities.<sup>4-5</sup> Although several studies have compared the associations between socioeconomic position and health outcomes among adults in different countries,<sup>4-10</sup> despite a systematic search of the literature we were unable to find any previous studies comparing differences in the association between socioeconomic position and health outcomes in children from different countries.

The objective of this study was to examine the association between socioeconomic position and insulin resistance in children from three countries in northern Europe (Denmark), eastern Europe (Estonia), and southern Europe (Portugal) that have different physical, economic, and cultural environments. These countries have important differences and similarities that could provide insights into the effects of socioeconomic position on insulin resistance. For example, Estonia differs from the other two countries in terms of a recent experience of marked social, cultural, and economic change, whereas Denmark differs from both Estonia and Portugal (two of the poorest countries in Europe) in being one of the richest countries in Europe.<sup>10</sup>

### Methods

We used data from the three countries in the European youth heart study—Denmark (Odense), Estonia (Tartu), and Portugal (Madeira).<sup>11</sup> We randomly selected boys and girls aged 9 and 15 years.<sup>11</sup> The overall participation was similar in each country (75% in Denmark, 76% in Estonia, and 73% in Portugal), and in total 3317 children (1019 from Denmark, 1174 from Estonia, and 1124 from Portugal) participated.

Children had a physical examination, including measurement of weight, height, waist circumference, skinfold thickness, and blood pressure. Measurements were made between September 1997 and June 1998 in Denmark, between September 1998 and June 1999 in Estonia, and between January 1999 and

Department of Social Medicine, University of Bristol, Bristol BS8 2PR

Debbie A Lawlor senior lecturer in epidemiology and public health medicine  
George Davey Smith professor of clinical epidemiology

Department of Exercise and Health Sciences, University of Bristol

Angie S Page lecturer in exercise and health sciences

Estonian National Institute for Health Development, Tallin, Estonia  
Maarike Harro director general

Institute of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark  
Niels Wedderkopp consultant orthopaedic surgeon and senior public health researcher  
Karsten Froberg associate professor

Department of Sports Medicine, Norwegian University of Sport and Physical Education, Oslo, Norway

Lars Bo Andersen professor  
Sigmund A Anderssen associate professor of physical activity and health

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Faculty of Human Movement, Technical University of Lisbon, Portugal

Luis B Sardinha  
*professor of exercise prescription*

London Sport Institute, Middlesex University, London

Chris J Riddoch  
*professor of exercise science and head of institute*

Department of Clinical Biochemistry, United Bristol Healthcare NHS Trust, Bristol  
David Stansbie  
*consultant in clinical biochemistry*

Correspondence to: D A Lawlor  
d.a.lawlor@bristol.ac.uk

June 2000 in Portugal. We estimated insulin resistance from fasting glucose and insulin according to the homoeostasis model assessment (HOMA).<sup>12</sup>

We classified parental education into four categories (basic/primary; secondary/trade apprentice; higher vocational qualifications; university). For each country we calculated mean family income as the mean of both parents' income category and collapsed it into five categories. We used multivariable linear regression models to assess the associations of parental education and family income with insulin resistance.

## Results

Of all participants, 933 (92%) of those from Denmark, 1153 (98%) of those from Estonia, and 1103 (98%) of those from Portugal had data from blood assays. Table 1 shows the characteristics of the study participants. We found no evidence of differences in the associations of family income and parental education with insulin resistance by sex or age group.

In Denmark, children from families with higher incomes and whose parents were better educated had lower HOMA scores than did those from lower income families and whose parents were less well educated (table 2). In Estonia and Portugal, we found associations in the opposite direction (P for difference <0.001 between Denmark and Estonia and between Denmark and Portugal). Although many of the

associations with other metabolic risk factors were imprecise, children from Denmark who were from lower income families and whose parents had received the lowest levels of education tended to have the worst risk factor profiles, with the opposite being the case for Estonia and Portugal (see [bmj.com](http://bmj.com)). Family income and parental education were positively associated with fitness in children from Denmark, but no strong associations existed in either Estonia or Portugal.

The inverse associations in Danish children and positive associations in Estonian and Portuguese children remained after adjustment for age, sex, parental body mass index, birth weight, breast feeding, height, pubertal stage, and measures of childhood adiposity and fitness (table 2). After adjustment for parental education, the associations between family income and insulin resistance attenuated towards the null in all three countries, but the associations between parental education and insulin resistance remained after adjustment for family income and all other covariates. Statistical evidence of a difference between the effect of maternal and paternal education in Denmark and in the other two countries remained in the fully adjusted models (P=0.03 for difference between Denmark and Estonia in maternal education and P<0.001 for paternal education; P<0.001 for difference between Denmark and Portugal for both maternal and paternal education).

## Discussion

We have found that Danish children from poorer families compared with more affluent families, and with less educated parents compared with better educated parents, have greater insulin resistance. In contrast, Estonian and Portuguese children from poorer families and with less educated parents have lower insulin resistance than those from more affluent families and with better educated parents.

### Strengths and limitations of study

The response rate for each country was high, but we have no socio-demographic data on non-responders. Comparing effects of indicators of socioeconomic position between countries is difficult because these tend to be culture specific and may have different meanings in different countries. Furthermore, measurement error may differ between countries. However, the similar associations between height and each measure of socioeconomic position in the three countries (see [bmj.com](http://bmj.com)) suggest that no marked differences in measurement error exist between the countries in the socioeconomic position indicators and that these indicators in each country do reflect socioeconomic position (as height is a potent marker of early life socioeconomic experience<sup>13</sup>). The meaning of family income may in particular vary between the three countries, as the relation of this to disposable material resources will be influenced by several factors such as mean family size, sources of unofficial income, and differences in welfare provision between the countries. However, the associations between parental education and insulin resistance were marked and linear (as seen in the figure on [bmj.com](http://bmj.com)).

**Table 1** Characteristics of participants. Values are means (SDs) unless stated otherwise

Characteristic	Denmark (n=933)	Estonia (n=1103)	Portugal (n=1153)
Age (years)	12.3 (2.9)	12.6 (3.0)	12.8 (3.0)
No (%) female	488 (52)	539 (49)	626 (54)
HOMA score*	2.05 (1.80)	1.73 (1.86)	1.56 (1.76)
Triglyceride (mmol/l)*	0.86 (1.47)	0.71 (1.47)	0.60 (1.55)
HDL-C (mmol/l)	1.42 (0.29)	1.42 (0.30)	1.44 (0.31)
Systolic blood pressure (mm Hg)	109.0 (10.0)	105.8 (11.6)	100.4 (10.3)
BMI (kg/m <sup>2</sup> )	18.9 (3.1)	18.5 (3.1)	19.8 (3.6)
Skinfold (mm)	40.7 (19.5)	32.6 (14.9)	42.6 (20.5)
Waist (cm)	63.5 (8.2)	62.5 (8.0)	66.3 (9.1)
Height (cm)	152.5 (16.7)	153.6 (17.5)	151.5 (15.6)
Fitness (W/kg)	3.16 (0.64)	2.98 (0.59)	2.52 (0.74)
Birth weight (g)	3353.2 (561.5)	3525.4 (586.8)	3365.2 (524.4)
No (%) breast fed >1 month†	683/913 (75)	707/1052 (67)	544/1035 (53)
Maternal BMI (kg/m <sup>2</sup> )	23.6 (3.9)	24.1 (4.2)	25.9 (4.0)
Paternal BMI (kg/m <sup>2</sup> )	25.3 (3.4)	25.9 (3.7)	26.4 (3.6)
Maternal education level—No (%):			
Primary	277 (32)	42 (4)	120 (12)
Secondary	103 (12)	284 (27)	728 (70)
Higher	137 (16)	360 (34)	109 (11)
University	343 (40)	365 (35)	81 (8)
Paternal education level—No (%):			
Primary	232 (28)	82 (9)	142 (15)
Secondary	54 (7)	258 (27)	674 (70)
Higher	232 (28)	295 (31)	109 (11)
University	306 (37)	316 (33)	45 (5)
Mean family income—No (%):			
Lowest	57 (6)	91 (9)	380 (40)
2	120 (13)	295 (28)	210 (22)
3	250 (28)	311 (30)	208 (22)
4	282 (31)	217 (21)	77 (8)
Highest	191 (21)	134 (13)	74 (8)

BMI=body mass index; HDL-C=high density lipoprotein cholesterol; HOMA=homoeostasis model assessment (insulin resistance).

\*Geometric means (SDs).

†Percentage is for number with complete data on this variable—not all participants had complete data.

**Table 2** Multivariable associations of family income and parental education with insulin resistance in children from Denmark, Estonia, and Portugal: unadjusted and adjusted differences (95% confidence intervals) in HOMA (%) between highest and lowest levels of each factor in each country

	Unadjusted	Model*								
		1	2	3	4	5	6	7	8	9
<b>Income</b>										
Denmark	-22 (-34 to -9)	-23 (-37 to -9)	-22 (-36 to -8)	-22 (-36 to -8)	-23 (-38 to -9)	-28 (-43 to -14)	-21 (-35 to -7)	-14 (-28 to -1)	-12 (-26 to 1)	-8 (-22 to 5)
Estonia	12 (1 to 24)	11 (-1 to 25)	11 (-1 to 25)	11 (-1 to 25)	10 (-2 to 24)	9 (-2 to 23)	9 (-2 to 23)	11 (-1 to 25)	9 (-2 to 23)	3 (-8 to 15)
Portugal	13 (2 to 25)	17 (3 to 23)	19 (4 to 34)	18 (3 to 33)	18 (3 to 33)	16 (2 to 31)	16 (2 to 31)	15 (1 to 29)	14 (-1 to 29)	9 (-5 to 22)
<b>Maternal education</b>										
Denmark	-22 (-35 to -9)	-24 (-38 to -10)	-24 (-38 to -9)	-24 (-38 to -10)	-25 (-40 to -10)	-26 (-41 to -12)	-21 (-35 to -7)	-17 (-31 to -3)	-20 (-36 to -5)	-16 (-31 to -1)
Estonia	15 (3 to 28)	15 (2 to 28)	14 (1 to 28)	15 (2 to 28)	15 (2 to 28)	14 (1 to 28)	13 (0 to 26)	10 (-4 to 24)	10 (-4 to 24)	4 (-11 to 19)
Portugal	22 (8 to 36)	19 (2 to 36)	20 (3 to 36)	19 (2 to 36)	19 (1 to 36)	18 (1 to 34)	19 (2 to 36)	15 (-1 to 31)	15 (-1 to 31)	17 (0 to 32)
<b>Paternal education</b>										
Denmark	-18 (-31 to -4)	-17 (-31 to -2)	-16 (-30 to -1)	-17 (-31 to -2)	-18 (-32 to -3)	-19 (-34 to -5)	-13 (-27 to 0)	-9 (-24 to 5)	-13 (-27 to 0)	-16 (-30 to 0)
Estonia	15 (3 to 28)	14 (0 to 28)	14 (0 to 28)	14 (0 to 28)	14 (0 to 28)	14 (0 to 28)	16 (2 to 29)	16 (2 to 30)	14 (0 to 28)	14 (0 to 28)
Portugal	26 (12 to 40)	27 (9 to 44)	32 (14 to 50)	27 (9 to 44)	27 (9 to 44)	20 (3 to 37)	20 (4 to 37)	23 (6 to 40)	23 (6 to 40)	20 (3 to 37)

HOMA=homoeostasis model assessment of insulin resistance.

\*Model 1=age and sex; model 2=age, sex, and parental body mass index (BMI); model 3=age, sex, and birth weight; model 4=age, sex, and breast feeding; model 5=age, sex, height, pubertal stage, and height\*age interaction term; model 6=age, sex, BMI, waist circumference, and mean skinfold thickness; model 7=age, sex, and fitness; model 8=age, sex, parental BMI, birth weight, breast feeding, height, pubertal stage, BMI, waist circumference, skinfold thickness, and fitness; model 9=age, sex, parental BMI, birth weight, breast feeding, height, pubertal stage, BMI, waist circumference, skinfold thickness, fitness, and maternal and parental education in the association with family income and family income in the associations with maternal and paternal education.

### Socioeconomic position, insulin resistance, and cardiovascular disease in European populations

The direction of the associations among children from Denmark is consistent with findings of an association between poorer childhood socioeconomic position and greater insulin resistance in adulthood in a study of British women,<sup>2</sup> and of associations between poorer childhood socioeconomic position and heart disease in adulthood in several northern and western European countries and in the USA.<sup>1-14</sup> Among adults in Estonia and other former Soviet Union countries, poorer educational attainment has been found to be associated with reduced life expectancy.<sup>15-17</sup> Mortality from coronary heart disease in Estonian adults declined in all educational groups between 1991 and 2000, but the decline was considerably greater in those with university education than in those with lower educational attainment.<sup>15</sup> Estonia regained its political independence in 1991 after 50 years of Soviet rule and on regaining independence opted for pronounced free market reforms. Policies including international trade agreements, foreign ownership of companies, and reduced employment protection were introduced.<sup>18</sup> The worsening fate of adults with lower educational attainment has been suggested to be in part due to their absolute and relative increase in poverty related to these reforms and in part because they are less able to cope with the marked social, economic, and cultural changes that have occurred since 1991.<sup>19</sup> Among Portuguese adults, poorer socioeconomic position also seems to be associated with poorer health.<sup>10-20</sup> However, in one study social class was not related to mortality from cardiovascular disease in Portugal, whereas other countries showed increased cardiovascular disease mortality among people from manual social classes.<sup>20</sup>

These findings among adults from Estonia and Portugal are in stark contrast to our finding among children from these two countries that low socioeconomic position is associated with lower insulin resistance. These disparities may be because children from better off families in lower income countries adopt "Western" lifestyles more readily than do adults in these countries (children from more affluent families and with better

educated parents in both Estonia and Portugal were more obese than those from lower socioeconomic groups). Particularly in Estonia, the economic reforms resulted in an increase in the proportion of children living in poverty and also a greater availability of foods such as burgers, crisps, and processed foods.<sup>21</sup> Only children from more affluent families would be able to afford these foods in large quantities. However, further research would be needed to verify that children from more affluent backgrounds in Estonia and Portugal are adopting more unhealthy lifestyles compared with those in less affluent and less well educated families. The similarity in findings between Estonia and Portugal suggest that income rather than social upheaval after the collapse of the Soviet Union explains the positive associations between income and parental education and insulin resistance in children in these two countries.

### Public health implications

The difference in direction of the association between Denmark, one of the richest countries in Europe, and two poorer countries is similar to the social class crossover in mortality from coronary heart disease that is often described as having occurred over the 20th century in Britain, although the extent to which this truly occurred has been questioned.<sup>22</sup> Previous work in health inequalities among adults in Estonia has led to the recognition of a "particular need to tackle health inequalities in countries in transition."<sup>15</sup> Our results among children are an important reminder that socioeconomic inequalities are dynamic and vary between countries, over time, and between generations within the same country.<sup>3</sup> The higher levels of insulin resistance among children of better educated parents in Estonia and Portugal may be the result of adoption of Western lifestyles in this age group. Although other work suggests that these better educated parents themselves are likely to be experiencing better health outcomes than less well educated adults, these benefits may not be transferred to their children.

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### What is already known on this topic

Socioeconomic position in childhood is associated with future insulin resistance and coronary heart disease

### What this study adds

Among Danish children, those with the most educated and highest earning parents were the least insulin resistant

The opposite was true for children from Estonia and Portugal; those from the most educated and highest earning parents were the most insulin resistant

These results are a reminder that socioeconomic inequalities are dynamic and vary between countries, over time, and between generations within the same country

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## Commentary: Health inequalities and social dynamics in Europe

Denny Vågerö, Mall Leinsalu

Centre for Health Equity Studies (CHESS), Stockholm University/Karolinska Institutet, SE-106 91 Stockholm, Sweden

Denny Vågerö  
professor

Stockholm Centre on Health of Societies in Transition, Södertörn University College, SE-141 89 Huddinge, Sweden  
Mall Leinsalu  
lecturer

Correspondence to:  
D Vågerö  
[denny.vagero@chess.su.se](mailto:denny.vagero@chess.su.se)

Lawlor and colleagues make the valid point that health inequalities are dynamic and change over time and between countries.<sup>1</sup> Unexpectedly, in Estonia and Portugal they found that a high level of insulin resistance is more common among children of more highly educated parents. They ask whether this is because of the new wealth of these families, perhaps a preference for Western style “junk” food?

A well known, but often ignored, fact is that the social distribution of risk factors, disease, and mortality varies by disease entity, time period, and country. “Anomalies,” or deviations from the standard pattern of poorer people having poorer health, include breast cancer and malignant melanoma. Certain risk factors for heart disease, such as smoking or obesity, may previously have been more common among people who are wealthy; in some countries this is still so. Studies from several countries suggest that as coronary heart

disease became more common, its inverse class pattern among men became more pronounced, perhaps even preceded by a reversal some decades ago.<sup>2</sup> Similarly, the generally higher mortality rate ratios for circulatory diseases (comparing manual and non-manual workers) in northwestern Europe than in southern Europe may be a result of a “phase difference,” implying that those ratios will soon increase in the south.<sup>3</sup> Is what the authors report from Portugal, Estonia, and Denmark consistent with such a phase transition? We feel that this is more likely to be the case for Portugal (Madeira) than for Estonia (Tartu).

Health inequalities are indeed constantly changing, driven by the social dynamics of a country. Many paradoxes are hidden in this truth. For Russia, the standard pattern of mortality by education applies to both men and women, in spite of contrasting risk factor distributions, with many “anomalies”—for instance, in obesity