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Socio-economic position and coronary heart disease risk factors in youth

Findings from the Young Hearts Project in Northern Ireland

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Background: This study investigates the existence of socioeconomic differentials in behavioural and biological risk factors for coronary heart disease in young people from Northern Ireland, taking into account differences in biological maturation. Methods: A school-based prospective study, with measurements in 1989/1990 and 1992/1993. Socio-economic position was based on occupational level of the main family breadwinner. Behavioural risk factors included were physical inactivity, the intake of total energy, dietary fat and a number of micronutrients. Biological risk factors included were blood pressure, body fatness, lipoproteins and cardio-pulmonary fitness. Biological maturation was based on Tanner's stages. Participants: 251 boys and 258 girls who were measured at the age of 12 years and re-examined at the age of 15 years. Results: Cross-sectional analyses showed that socio-economic differences in cholesterol intake (in boys) and physical inactivity and total energy intake (in girls) were present at 12 and 15 years of age, while differences in fat and fruit intake and smoking behaviour (in boys and girls) became established at the age of 15 years, with unfavourable levels in subjects in the manual group. Longitudinal analyses confirmed that differences in behavioural risk factors exist or develop during adolescence. No clear pattern of differences in biological risk factors was found by socio-economic position. Adjustment for biological maturation did not materially alter the results. Conclusion: Differences in lifestyle by socio-economic position seem to become established in adolescence. These differences however, are not (yet) reflected in differences in biological risk factors by socio-economic position.

Keywords: adolescence, behavioural risk factors, biological risk factors, CHD, socio-economic position

Coronary heart disease (CHD) is still the leading cause of mortality in many industrialised societies. It is now established from prospective research that CHD morbidity and mortality differ by socio-economic position, with higher rates in subjects in the lower socio-economic strata.[1] The socio-economic patterning of CHD is reflected in socio-economic differences in the prevalence of biological risk factors, such as hypertension, hypercholesterolaemia, low cardio-respiratory fitness, obesity and behavioural risk factors, such as physical inactivity, smoking and micro-nutrient deficiency in adulthood.[2] There are, however, additional exposures which may increase the risk of CHD among people in less favourable circumstances, including low birth weight, poor growth in childhood and psychosocial factors acting in adulthood.[3]

It is known that the process underlying CHD, atherosclerosis, starts in childhood and youth.[4] Elevated levels of biological risk factors are already apparent in youth and, to a certain degree, predict the degree of risk in adulthood.[5–8] Further development of unfavourable patterns of behavioural risk factors in youth is a matter of concern. Hence, in order to improve population-based preventive strategies there is a need to identify the determinants of these biological and behavioural risk factors during youth. Despite the relative consistency in the socio-economic gradient in risk factors of CHD in adulthood, it is less clear at which stage in life these socio-economic differences are established.

Studies of the association between socio-economic position and biological risk factors in childhood and adolescence have thus far produced inconsistent results. It has been suggested that this may be, at least partly, due to differences in the ages of the populations under study.[9] Given the fact that differences in risk by socio-economic

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position are apparent in adulthood, it could be hypothesised that they develop during adolescence. It has further been hypothesised that socio-economic differences in behavioural risk factors precede the development of socio-economic differences in some biological risk factors during youth.[10]

Adolescence is characterised by the transition from childhood into adulthood, through the process of biological maturation. There is evidence that mean levels of biological and behavioural risk factors differ according to the timing of biological maturation.[11,12] If there is an association between biological maturation and socio-economic position, as for example found in a study in Finland,[13] differences in mean values of biological and behavioural risk factors by stage of biological maturation could mask or explain the associations between socio-economic position and these risk factors and further contribute to the inconsistencies in findings presented thus far.

Northern Ireland faces one of the worlds' highest mortality rates for CHD.[14] To provide detailed information for the need and direction of preventive strategies in youth, a prospective cohort study, the Young Hearts Project, was initiated in Northern Ireland in 1989/1990.[15] The present study investigates the existence of social class differences in behavioural and biological risk factors at the age of 12 and 15 years, taking into account differences in biological maturation.

MATERIAL AND METHODS

Population

The Young Hearts Project is a school-based prospective study, aimed at investigating the development of biological and behavioural risk factors for CHD. Details of the study design and sampling procedure have been presented elsewhere.[15] In the original cross-sectional survey in 1989/1990, random samples of 12 and 15 year-old boys and girls participated in the study (boys 12 year: N=251; boys 15 year: N=252; girls 12 year: N=258; girls 15 year: N=254; overall response rate: 78%). In 1992/1993, the initially 12 year-old boys and girls were re-examined under identical conditions (response rate: 87%). Reasons for non-participation in the follow-up were refusal (N=9), illness (N=25); moving from school (N=17) or other reasons (N=3). Only data for children aged 12 years at baseline were included in this study. Analyses for each risk factor were performed in participants without missing information on that risk factor at both periods of measurement, socio-economic position at the age of 12 years and biological maturation at both periods of measurement.

Socio-economic position

As an indicator of the socio-economic position of the children, information about the occupation of the main breadwinner in the family was collected at the first period of measurement and categorised using the Standard Occupational Classification of the Office of Population Censuses and Surveys Statistics (OPCS).[16] The original six categories (professionals; managerial and technical occupations, skilled non-manual occupations; skilled manual occupations; partly skilled occupations and unskilled occupations) were dichotomised into a non-manual (upper three classes) and manual (lower three classes) social class.

Behavioural risk factors

Information about physical activity was obtained from a questionnaire, including aspects of everyday physical activity (such as methods of transportation to and from school, activities during breaks in the school days and sports participation after school), which was previously used in another large-scale study in Northern Ireland.[17] In the computation of the activity score, frequency, intensity and duration of the activities were taken into account. This resulted in a weighted activity score, varying between 0 and 100. Although validation of the questionnaire is complex in the absence of a gold standard, associations with physical fitness suggest the questionnaire to be a good instrument for the purpose of this study.[18]

A dietary history method was used to collect information about the nutritional intake.[19] Questions were open-ended and a photographic atlas, including more than 170 photographs, was used to determine portion sizes. From this information, total energy and nutrient intake were calculated, using a computerised database. In the present study, total energy intake (MJ/day) and fat intake (expressed as a percentage of total energy intake) were included. Given their protective effect against CHD, we further included the intake of vegetables and fruit (both expressed as a percentage of total energy intake), fibre (g/day), cholesterol intake (mg/MJ/day) and the polyunsaturated to saturated fat ratio (P:S ratio).[20,21] Information about smoking was obtained from a confidential recall questionnaire, including questions about the number of cigarettes smoked per week. Those who admitted smoking at least one cigarette per week were characterised as smokers.

Biological risk factors

Systolic (SBP) and diastolic blood pressure (DBP) were measured twice from the right arm, using a Hawksley random zero sphygmomanometer and with the subjects sitting quietly beforehand for at least five minutes. At the age of 12 years, SBP was determined as the mean value of the first Korotkoff phase. DBP was determined as the mean value of the fourth Korotkoff phase (at the age of 12 years) or the fifth Korotkoff phase (at the age of 15 years).

A non-fasting blood sample was drawn from the antecubital vein. From this sample, total serum cholesterol (TC) was estimated by an enzymatic technique (CHOD-PAP, Boehringer, Mannheim). The concentration of high-density lipoproteins (HDL) was estimated by phosphotungstic magnesium reagents.[22]

Anthropometrical measurements included body height and weight. From these data BMI was calculated as weight (kg) divided by the height squared (m^2). Further, four skinfold thicknesses (biceps, triceps, subscapular and suprailiac) were estimated, according to Durnin and Rahaman, and their sum (SSF) was also used as an indicator of body fatness.[23] Participants carried out a 20 metre endurance shuttle run test and the number of completed laps was used an indicator of cardio-respiratory fitness. A detailed description about the measurement procedures is presented elsewhere.[24]

Biological maturation

Biological maturation was based on Tanner's pubic hair stages.[25] At the age of 12 years, boys and girls in the first Tanner stage were characterised as slowly maturing, while those in higher stages were characterised as rapidly maturing. At the age of 15 years, rapidly maturing boys and girls were those in the final stage, while slowly maturing boys and girls had not yet reached that stage.

Statistical analysis

Independent sample t-tests were used to describe the mean values of risk factors by socio-economic position at the age of 12 and 15 years separately. In addition, a longitudinal data-analysis technique was used to test the overall significance of differences in the risk factors by socio-economic position at both periods of time simultaneously. Therefore, the technique of generalised estimating equations (GEE) was used.[26] In this technique, data from several periods of measurements are included in one analysis, in which adjustment is made for the dependence of the data in the same subjects. As a result, the number of data points in the analyses – and hence the power of the tests – increases substantially. Its use in epidemiological studies has been described in detail by Twisk et al.[27] In short, it may be regarded as a (linear) regression technique with time-dependent variables (for example age) and time-independent variables (for example gender). We used GEE to evaluate the effects of socio-economic position at the age of 12 years (time-independent variable) on the behavioural and biological risk factors measured at both periods of time (time-dependent variables), adjusted for the period of measurement (time-dependent variable). The resulting regression coefficients for socio-economic position can be interpreted similarly as in cross-sectional linear regression analysis, although estimated using both periods of measurement. In the model a (socio-economic position * period of measurement) interaction term was included to test whether the association between socio-economic position and behavioural and biological risk factors changed between the periods of measurement.

In order to investigate the effects of biological maturation on the association between socio-economic position and the biological risk factors, we first investigated the association between socio-economic position and biological maturation, using chi-square tests. Subsequently, analysis of variance was used to investigate the effect of biological maturation at the age of 12 and 15 year separately, while GEE was used to test the effect of biological maturation (a time-dependent variable) over the entire period of research.

RESULTS

Tables 1 and 2 present the mean values of the behavioural risk factors in boys and girls, respectively. In general, the patterns are rather similar for boys and girls. Total energy intake in subjects in the manual group was significantly higher compared to that in subjects in the non-manual group at the age of 12 years, and also at the age of 15 years in girls (but not in boys). Dietary cholesterol intake was higher in the manual group in boys and girls at the age of 12 years, and also at the age of 15 years in boys (but not in girls). At the age of 15 years, dietary fat intake (as a percentage of the total energy intake) was significantly higher in the manual group compared to the non-manual group. At that age, boys and girls in the manual group consumed significantly less fruit compared to subjects in the non-manual group. In boys, the P:S ratio was significantly lower in the manual group at the age of 12 years. Contrary to expectation, fibre intake was significantly higher in girls in the manual group at the age of 15 years. Total physical activity was borderline lower in girls in the manual group at the age of 12 years ($p=0.06$) and significantly lower at the age of 15 years. At the age of 12 years, only 5 boys and 3 girls smoked at least one cigarette per week, and therefore, no meaningful comparison could be made between the percentage of smokers in the manual and non-manual groups. In the manual group, a significantly higher percentage of boys and girls smoked than in the non-manual group at the age of 15 years.

The cross-sectional results were confirmed in the longitudinal analysis (not shown), including the measurements at 12 and 15 years of age simultaneously. A significant effect of socio-economic position on total energy intake was found ($\beta=4.04$, $p<0.01$) in boys. The fact that this difference was only apparent at the age of 12 years was reflected in a significant (socio-economic position * period of measurement) interaction effect ($\beta= -1.88$, $p<0.01$). A main effect of socio-economic position was also found for the intake of dietary fat ($\beta=1.05$, $p=0.02$), dietary cholesterol ($\beta=52.5$, $p=0.00$), fruit ($\beta= -0.42$, $p=0.03$) and the P:S ratio ($\beta= -0.04$, $p=0.01$). Although t-tests showed only effects of socio-economic position on fat intake, fruit intake and the P:S ratio at one period of measurement, no significant interaction effects were found in the longitudinal analyses. For girls, main effects were found for physical activity ($\beta= -3.04$, $p<0.01$), total energy intake ($\beta=1.02$, $p=0.01$) and the intake of dietary fat ($\beta=1.10$, $p=0.01$), cholesterol ($\beta=93.0$, $p=0.01$) and fruit ($\beta= -0.87$, $p=0.01$). The finding that there is only an effect of socio-economic position on dietary cholesterol intake at the age of 12 years was reflected in a significant interaction ($\beta= -42.7$, $p=0.02$). No significant interaction effect was found for the intake of dietary fat, fruit and fibre intake. Due to the limited number of smokers at the age of 12 years, we did not investigate the effects of smoking on socio-economic position longitudinally.

Tables 3 and 4 present the mean values of the biological risk factors by socio-economic position in boys and girls, respectively. In boys, there appeared to be no statistically

Table 1 Mean values (sd) of behavioural risk factors by social class in 12 and 15-year-old boys

	N	Non-manual		N	Manual		p
12-year-old boys							
Physical activity	116	32.8	(13.4)	82	33.7	(14.4)	0.63
Total energy intake (MJ/day)	116	10.4	(2.5)	83	12.6	(3.4)	<0.00[c]
Fat intake (%)	116	38.3	(4.2)	83	39.1	(3.8)	0.15
Vegetable (%)	116	1.5	(1.1)	83	1.3	(0.9)	0.17
Fruit (%)	116	2.4	(2.2)	83	2.1	(1.9)	0.27
Fibre (g/day)	116	21.0	(8.5)	83	20.6	(5.8)	0.70
Cholesterol (mg/MJ/day)	116	187	(118)	83	250	(166)	0.02
P:S ratio[a]	116	0.39	(0.16)	83	0.32	(0.13)	0.01
% smokers[b]							
15-year-old boys							
Physical activity	116	28.1	(14.1)	82	26.6	(12.7)	0.45
Total energy intake (MJ/day)	116	13.1	(3.2)	83	13.5	(2.9)	0.42
Fat intake (%)	116	37.1	(4.5)	83	38.7	(3.9)	<0.00
Vegetables (%)	116	1.5	(0.9)	83	1.4	(1.0)	0.28
Fruit (%)	116	2.1	(1.7)	83	1.6	(1.5)	0.05
Fibre (g/day)	116	26.4	(8.4)	83	25.7	(7.0)	0.52
Cholesterol (mg/MJ/day)	116	204	(115)	83	262	(147)	0.03
P:S ratio	116	0.43	(0.18)	83	0.41	(0.17)	0.34
% smokers	112	17.9		80	28.8		0.05[d]

a P:S ratio = poly-unsaturated to saturated fat ratio
b: Number of smoking subjects too small
c: p-value of t-test, assuming unequal variances, based on Levine's test for equality of variances
d. p-value of the chi-square test for the association between smoking behaviour and socio-economic position

Table 2 Mean values (sd) of behavioural risk factors by social class in 12 and 15-year-old girls

	N	Non-manual		N	Manual		p
12-year-old girls							
Physical activity	124	26.4	(13.1)	74	22.7	(14.1)	0.06
Total energy intake (MJ/day)	126	9.0	(2.4)	73	9.9	(2.6)	0.02
Fat intake (%)	126	38.6	(4.5)	73	39.2	(4.4)	0.38
Vegetable (%)	126	1.7	(1.1)	73	1.5	(1.3)	0.48
Fruit (%)	126	3.1	(2.3)	73	2.5	(2.5)	0.10
Fibre (g/day)	126	18.5	(5.9)	73	18.8	(5.4)	0.73
Cholesterol (mg/MJ/day)	126	152	(80)	73	197	(101)	0.01[c]
P:S ratio[a]	126	0.40	(0.15)	73	0.44	(0.19)	0.19
% smokers[b]							
15-year-old girls							
Physical activity	126	18.6	(10.5)	74	15.5	(10.8)	0.05
Total energy intake (MJ/day)	126	8.9	(2.1)	73	9.9	(2.8)	0.01[c]
Fat intake (%)	126	38.3	(4.0)	73	39.7	(3.9)	0.02
Vegetable (%)	126	1.5	(1.1)	73	1.6	(1.3)	0.73
Fruit (%)	126	3.4	(2.8)	73	2.2	(2.1)	0.02
Fibre (g/day)	126	17.7	(5.5)	73	19.6	(6.6)	0.03
Cholesterol (mg/MJ/day)	126	141	(90)	73	148	(81)	0.54
P:S ratio	126	0.46	(0.19)	73	0.45	(0.22)	0.74
% smokers	124	13.7		73	27.4		0.02[d]

a: P:S ratio = poly-unsaturated to saturated fat ratio
b: Number of smoking subjects too small
c: p-value of t-test, assuming unequal variances, based on Levine's test for equality of variances
d: p-value of the chi-square test for the association between smoking behaviour and socio-economic position

Table 3 Mean values (sd) of biological risk factors by social class in 12 and 15-year-old boys

	N	Non-manual		N	Manual		p
12-year-old boys							
SBP (mmHg)	117	111	(12)	87	111	(11)	0.74
DBP (mmHg)	117	68	(9)	85	68	(10)	0.67
TC (mmol/l)	116	4.69	(0.88)	83	4.47	(0.78)	0.06
HDL (mmol/l)	116	1.40	(0.33)	83	1.43	(0.32)	0.54
TC/HDL	116	3.53	(1.06)	83	3.28	(0.92)	0.09
Height (m)	116	1.50	(0.8)	82	1.49	(0.8)	0.12
BMI (kg/m^2)	116	19.2	(3,5)	82	18.9	(3.3)	0.65
SSF (mm)	116	39	(21)	82	38	(22)	0.77
20 MST (laps)	111	61	(20)	78	56	(18)	0.11
15-year-old boys							
SBP (mmHg)	117	117	(11)	87	115	(10)	0.22
DBP (mmHg)	117	63	(8)	85	64	(9)	0.51
TC (mmol/l)	116	3.78	(0.66)	83	3.70	(0.65)	0.38
HDL (mmol/l)	116	1.14	(0.24)	83	1.24	(0.30)	0.01[a]
TC/HDL	116	3.46	(0.90)	83	3.14	(0.90)	0.02
Height (m)	116	1.72	(0.7)	82	1.69	(0.8)	0.02
BMI (kg/m^2)	116	21.1	(3.1)	82	20.8	(3.8)	0.67
SSF (mm)	116	34	(18)	82	32	(19)	0.55
20 MST (laps)	111	85	(21)	78	81	(21)	0.29

SBP: systolic blood pressure; DBP: diastolic blood pressure;
TC: total serum cholesterol; HDL: high density lipoproteins;
BMI: body mass index; SSF. sum of four skinfolds;
20 MST· 20 metre shuttle run test
a: p-value of t-test, assuming unequal variances, based on Levine's test for equality of variances

Table 4 Mean values (sd) of biological risk factors by social class in 12 and 15-year-old girls

	N	Non-manual		N	Manual		p
12-year-old girls							
SBP (mm Hg)	130	111	(13)	77	112	(11)	0.61
DBP (mm Hg)	128	71	(9)	77	70	(10)	0.58
TC (mmol/l)	126	4.76	(0.80)	74	4.76	(0.78)	0.98
HDL (mmol/l)	126	1.37	(0.32)	74	1.41	(0.27)	0.40
TC/HDL	126	3.64	(0.93)	74	3.48	(0.81)	0.23
Height (m)	125	1.52	(0.7)	74	1.51	(0.8)	0.28
BMI (kg/m^2)	125	19.2	(2.8)	74	19.2	(3.2)	0.75
SSF (mm)	125	44	(15)	74	42	(17)	0.44
20 MST (laps)	123	45	(13)	70	44	(12)	0.85
15 year-old girls							
SBP (mm Hg)	130	110	(10)	77	109	(9)	0.43
DBP (mm Hg)	128	66	(8)	77	64	(8)	0.17
TC (mmol/l)	126	4.25	(0.69)	74	4.14	(0.76)	0.30
HDL (mmol/l)	126	1.37	(0.28)	74	1.35	(0.30)	0.56
TC/HDL	126	3.23	(0.83)	74	3.19	(0.81)	0.82
Height (m)	125	1.63	(0.6)	74	1.60	(0.6)	0.01
BMI (kg/m^2)	125	21.6	(2.9)	74	21.4	(3.6)	0.67
SSF (mm)	125	50	(16)	74	48	(17)	0.55
20 MST (laps)	123	48	(15)	70	45	(15)	0.16

SBP: systolic blood pressure; DBP: diastolic blood pressure;
TC: total serum cholesterol; HDL: high density lipoproteins;
BMI: body mass index; SSF· sum of four skinfolds;
20 MST = 20 metre shuttle run test

significant differences in risk factors levels by socio-economic position at the age of 12 years. For SBP, DBP, BMI, SSF and the 20-MST, no significant differences were found at the age of 15 years either, with still very small absolute differences in mean values, except for TC. The non-significant absolute difference in TC between the non-manual and manual groups at the age of 12 years was reduced at the age of 15 years. At that age, and contrary to expectation, HDL was significantly higher and the TC/HDL ratio was significantly lower in the manual group compared to the non-manual group. At the age of 15 years, boys and girls in the manual group were significantly shorter. No other significant differences were found in mean values of the risk factors by socio-economic position at the age of 12 and 15 years in girls and the absolute differences remained very small. In the longitudinal analysis, a main effect of socio-economic position was found for TC (β= –0.32, p=0.05) in boys after inclusion of a significant (socio-economic position * period of measurement) interaction term. The increasing difference in HDL by socio-economic position over time was reflected in a significant interaction (β=0.07, p=0.02). In the absence of a main effect of socio-economic position, a significant interaction effect was found for the TC/HDL ratio in boys (β=0.07, p=0.02). A significant effect of socio-economic position on body height was found in both boys (β= –2,29, p=0.02) and girls (β=20.0, p=0.02). In girls, no other significant main or interaction effects were found in the longitudinal analysis.

Table 5 shows the number and percentages of rapidly and slowly maturing boys and girls by socio-economic position. There was no association between socio-economic position and maturation among 12-year-old boys, while a higher proportion of non-manual girls was classified as slow maturers at that age. At the age of 15 years, a higher proportion of non-manual boys was classified as rapid maturers than manual boys. None of these differences, however, appeared to be statistically significant. Due to these weak findings, adjustment for biological maturation was not expected to affect the association between socio-economic position and biological risk factors. This was confirmed in the analyses of variance. Such an adjustment did not affect the reported significant differences by socio-economic position group in boys and girls. There appeared to be no association between smoking behaviour and biological maturation in boys at the age of 15 years and hence, biological maturation could not affect the reported associations between smoking behaviour and socio-economic position. No significant interactions between biological maturation and socio-economic position were found for the behavioural variables. Inclusion of biological maturation in the longitudinal analyses did not materially alter the results.

DISCUSSION

The present study investigated the effects of socio-economic position on behavioural and biological risk factors at the age of 12 and 15 years in boys and girls from Northern Ireland, both separately and simultaneously. Furthermore, we were able to investigate if adjustment for biological maturation affected the association between socio-economic position and behavioural and biological risk factors. In general, we found that behavioural risk factors were more unfavourable in subjects in the manual group compared to subjects in the non-manual group, particularly at the age of 15 years. This was, except for an increased body height in the higher compared to the lower socioeconomic group at the age of 15 years, not yet reflected in differences in biological risk factors by socio-economic position in youth. HDL was found to be higher and the TC/HDL ratio lower in boys in the manual group. There appeared to be only a weak association between biological maturation and socio-economic position and consequently, adjustment for biological maturation minimally affected these findings.

Some methodological problems may have influenced our results. First, non-response may reduce the external validity of the results. The sampling procedure aimed at selecting a sample of approximately 250 children in four age–sex groups (12 and 15-year-old boys and girls), taking into account geographical spread and different categories of schools in Northern Ireland. These numbers amounted to a 2% random sample of each group in the province. The overall response rate was 78%; reasons for non-

Table 5 Numbers and percentages of rapidly and slowly maturing boys and girls by social class at the age of 12 and 15 years

	12-year-old				15-year-old			
	Rapid[a]		Slow		Rapid		Slow	
	N	%	N	%	N	%	N	%
Boys								
Non-manual	33	56.9	84	57.5	66	63.5	51	51.0
Manual	25	43.1	62	42.5	38	36.5	49	49.0
p-value			0.53				0.09	
Girls								
Non-manual	95	60.5	35	70.0	93	62.0	37	64.9
Manual	62	39.5	15	30.0	57	38.0	20	35.1
p-value			0.15				0.41	

a: Rapidly mature (12 years of age): Tanner stage 2–5; slowly mature: Tanner stage 1, rapidly mature (15 years of age): Tanner stage 5; slowly mature: Tanner stage 1–4 participation were obtained from 196 non-responders: objection to blood sampling, reluctance to do any part of the study, recent illness and parental opposition were the main reasons for refusal. There was therefore no indication of selective non-participation, based on health. Further, a prospective study always faces the problem of selective dropout. The external validity could therefore also be threatened by selective dropout of subjects according to risk factor levels or socio-economic position. Reasons for dropout, as mentioned earlier, did not suggest the occurrence of any selection in compliance. Further, due to the limited number of subjects in the study we could only create two socio-economic groups. Hence, differences in risk factor levels could not be compared by the original six social class categories of the OPCS. Misclassification of subjects according to occupation or social class of parents may have further resulted in a bias towards the null.[28]

Our finding of a higher percentage of smoking adolescents in the manual group is in line with other studies. In a representative sample of US adolescents, smoking was more prevalent in the lower socio-economic groups, either based on the educational level of the responsible adult or the family income.[29] De Vries, who also reported significant differences in the percentage of smoking adolescents between 10 and 15 years of age by socio-economic position, found that the perception of the association between smoking and adverse health outcomes was more clear in subjects in the high socio-economic position group.[30] Subjects in the low socio-economic position group felt more social pressure to smoke. It is suggested that peer pressure in adolescents is a more important predictor of smoking than low socio-economic position.[31,32] Contrary to these findings, a recently published study found no (linear) association between smoking behaviour and socio-economic position.[10] In the latter study, sports participation was the only behavioural factor linearly related to socio-economic position, which was also reported in a study in the US.[29] Sallis et al. investigated this association in more detail and found that total time per week of vigorous exercise out of school did not differ between subjects in a high and low socio-economic position group (defined by school district), as was found for girls in our study.[33] However, subjects in the high socio-economic position group were more frequently involved in a sport team and they had more activity lessons (perhaps because they could access such lessons more easily) and physical education classes per week.

Our finding of a higher fat intake in adolescents in the manual group seems to be relatively consistent with findings from other studies. Lowry et al. found a higher consumption of fat in food among girls with a lower compared to a higher socio-economic position, but not in boys.[29] Further, significantly more 15-year-old subjects from the non-manual compared to the manual class were characterised as healthy eaters (eating relatively less fat than carbohydrates) in Scotland.[34] Other studies reported higher fruit and vegetable consumption in adolescents with a higher compared to a lower socio-economic position.[35]

Despite these differences in diet composition by socio-economic position in adolescence, socio-economic position differences in mean BMI or SSF were not found in our study. In a recently published study, differences were found in the prevalence of obesity by socio-economic position in Belgian girls, mean aged 12.5 years, but not in boys.[36] Bergström et al. reported a higher mean BMI in adolescents in families with a low socio-economic position in 14 to 17-year-old adolescent girls.[32]

An interesting finding of our study is that boys and girls in the manual class are shorter compared to boys and girls in the non-manual class at the age 15 years. Such differences were not yet found at the age of 12 years. Although boys and girls at the age of 15 years have probably not reached their adult height, and hence manual class children could theoretically catch up again in body height, our finding is compatible with earlier research showing similar differences in adulthood. In a study by Kuh et al. (1989) father's occupation was still negatively associated with adult body height of their children, after adjustment for parental body height.[37] Body height is inversely associated with coronary heart disease mortality.[38] If the development of socioeconomic inequalities in health is considered in a life course perspective, the period of adolescence may contribute through constrained growth in the lower compared to the higher socioeconomic groups.

Except for HDL and the TC/HDL ratio in boys, we did not find other statistically significant differences in mean biological risk factor values by socio-economic position. However, such differences are often reported in adults. The question therefore remains at what stage in life these differences become clear. It suggests that the end of puberty and early adulthood could be of major importance for the development of socio-economic position differences. Socio-economic position differences at the end of puberty however, have been little investigated. Future research needs to investigate if differences in biological risk factors by socio-economic position develop at that period of life. Further, it should also address the mechanisms responsible for the development of socio-economic differences, and therefore use a prospective study design.

In a previous report, we expressed serious concern about the prevalence of hypertension, hypercholesterolaemia and obesity in youth from Northern Ireland.[15] The implication of the present findings is that prevention of CHD through biological risk factor modification in adolescence should not be specifically targeted at a particular socio-economic grouping, though it cannot be excluded that such an approach would be beneficial at a later stage of adolescence. Because manual class children show unfavourable values for behavioural risk factors compared to those in the non-manual class, programmes aimed at adopting a healthy lifestyle should already start in primary school, continue into secondary school and pay particular attention to children in the lower socio-economic groups.

In conclusion, in 12 and 15-year-old boys and girls, no clear differences seem to be established in biological risk factors of CHD, except for a greater body height in non-manual compared to manual boys and girls at the age of 15 years. Youth in manual groups however, have already, or develop, a less healthy lifestyle between 12 and 15 years of age compared to subjects in the non-manual group. It is suggested that socio-economic position differences in behavioural risk factors develop during adolescence, and will result in differences in biological risk factors at the end of puberty or during early adulthood. We are currently following up this cohort to test this hypothesis.

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