Coronary risk factors in schoolchildren

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Abstract

Death rates from coronary heart disease (CHD) in Northern Ireland are among the highest in the world. However, no data have been available to test the hypothesis that the high prevalence of CHD is reflected by the risk status of the childhood population. A randomly selected 2% population sample of 1015 children aged 12 and 15 years was studied to obtain baseline information on blood pressure, lipid profile, cigarette smoking, family history, physical activity, cardiorespiratory fitness, and dietary fat intake.

Using available criteria thresholds, 15-23% displayed increased blood pressure, 12-25% had unfavourable lipid profiles, and 18-34% were overfat. In 15 year old children, 16-21% admitted being regular smokers, 26-34% displayed poor cardiorespiratory fitness, and 24-29% reported little physical activity in the previous week. Dietary analysis revealed relatively low polyunsaturated to saturated fatty acid ratios and high mean fat intakes, accounting for approximately 40% total daily energy.

Despite the exclusion of family history from the analysis, 16% of the older children exhibited three or more risk factors. These results justify major concern about the level of potential coronary risk in Northern Ireland schoolchildren. Broadly based primary prevention strategies aimed at children are essential if future adult CHD mortality is to be reduced.

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Northern Ireland remains at the top of the world mortality league for coronary heart disease (CHD).¹ While numerous adult epidemiological studies have clearly established relationships between antecedent risk factors and subsequent coronary endpoints, it is only more recently that the risk factor model has been extended to children.²⁻³ The rationale for this approach is threefold: firstly, it is recognised that the seeds of CHD are sown in childhood, with postmortem studies demonstrating advanced atherosclerotic lesions as early as the second decade of life.⁴ Secondly, strong associations have been observed between antemortem risk factors and the extent of postmortem coronary atherosclerosis in young adolescents.⁵ Thirdly, the phenomenon of tracking, whereby an individual at the upper end of the distribution for a given risk factor tends to maintain that position relative to his or her peers⁶ lends credence to the validity of the risk factor approach in children.

The aim of the present study was to establish the nature and extent of factors associated with coronary risk in the children of Northern Ireland, the hypothesis being that the high incidence of CHD in the adult population would be reflected by risk status in its childhood population. Such information should prove invaluable in devising and monitoring public health strategies aimed at reducing levels of coronary risk from an early age.

Subjects and methods

The sampling procedure was designed to select a sample of approximately 250 children from each of the following four age-sex groups: 12 year old boys, 12 year old girls, 15 year old boys, 15 year old girls, taking into account geographical spread and the different categories of school in Northern Ireland. The target sample size of 250 was based on the variability of pilot study results.⁷ These numbers of children amount to a 2% random sample of each age population in the province.

Schools were stratified by education area board (representing five geographical regions) and within an area board by selection policy (selective=grammar, non-selective=secondary or comprehensive). From each stratum, a two stage cluster sample of children was obtained. The primary units were the schools that were selected with probability proportional to school size, resulting in a total of 16 schools. Within a chosen school, children were randomly selected from the school roll within the appropriate age-sex groups. The target number of pupils from a specific age-sex group in a school was determined by the selective:non-selective ratio for the given age-sex group and also by the proportions in different area boards. To allow for non-response the target numbers were increased by approximately 20%. An overall response rate of 78% resulted in a total of 1015 subjects being tested. Reasons for non-participation were obtained from 196 (63.2%) of non-responders. Of the remaining 114 (36.8%), 55 were officially absent from school while 37 were marked present but not traceable. A further 22 children felt unable to volunteer any reasons for non-response.

Objection to blood sampling emerged as the most commonly stated reason for non-response (n=69 children), followed by a reluctance to do any part of the study (n=37). Thirty four children gave recent illness or being under medical supervision, for example for asthma, as a reason for non-participation. Parental opposition cited either by the child or in writing from parents was also a prominent reason (n=37).

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Missing schoolwork ($n=17$), late return of consent forms ($n=8$), and previous participation ($n=3$) in a research project were other reasons given. There was therefore no recognisable pattern for non-participation likely to influence the validity of the random nature of the sample.

Ethical approval was secured beforehand and written consent obtained from the parent or guardian and participating children. The test protocol included a medical examination during which height, weight, and pubertal status were determined.⁸ Skinfold thicknesses were also obtained from four sites for the estimation of body composition according to the method of Durnin and Rahaman.⁹ Blood pressure was measured twice from the right arm, using a Hawksley random zero sphygmomanometer, with the subject sitting quietly for at least five minutes. Systolic blood pressure was recorded as the mean of the two values for Korotkoff phase I, while the diastolic blood pressure was based on the mean of two values for Korotkoff phase V (15 year olds) or Korotkoff phase IV (12 year olds). Non-fasting blood samples were drawn from the antecubital vein under local anaesthesia (lignocaine/prilocaine, Emla cream, Astra), and separated into serum/plasma within four hours. Total cholesterol concentration was estimated by an enzymatic technique (CHOD-PAP, Boehringer Mannheim) and high density lipoprotein cholesterol concentration by phosphotungstic magnesium reagents.¹⁰ These assays were carried out in a laboratory conforming to World Health Organisation standards. Nutritional information was collected by the diet history method,¹¹ with open ended interview and using a photographic atlas (>170 photographs) to determine portion sizes. Mean daily food intakes by this method are in closer agreement with energy expenditure measured by doubly labelled water than those obtained by weighed dietary record in a sample of 12 and 15 year old boys and girls from this population.¹² Nevertheless, to take account of possible under and over reporting using the diet history procedure, an edited sample was obtained as follows: a subject was omitted if his or her ratio of daily energy intake (MJ): calculated basal metabolic rate (MJ),¹³ was less than 1.3 or greater than 2.5. Values outside this range were considered

to be physiologically improbable and of doubtful validity. Energy and nutrient intakes were calculated using a computerised database. Activity patterns and smoking status were ascertained by means of a confidential seven day recall questionnaire.¹⁴ Children were classified into two physical activity groups according to whether they reported participating in any vigorous activity the previous week. These groups were further divided according to the median of an activity 'score', computed from questionnaire information on everyday physical activities (for example, method of transportation to school, sports participation after school, etc). This yielded a total of four activity groups. Cardiorespiratory fitness was determined by the 20 metre endurance shuttle run (20-MST).¹⁵ 20-MST scores were converted to a predicted maximal oxygen uptake ($\dot{V}O_2$ MAX) score using linear regression.¹⁶ Tests were carried out in the same order and by the same investigators throughout the study, and care was taken to minimise cross testing effects, for example, the 20-MST was carried out as a group after the physical examination and blood tests.

Thresholds of 'coronary risk' were assigned for each risk factor on the basis of published figures. Blood pressure cut off points approximated the 95th centile according to the National Institutes of Health second task force report on blood pressure,¹⁷ namely 126/82 mm Hg (12 years) and 136/86 mm Hg (15 years). A total cholesterol of 5.2 mmol/l was assigned a threshold of risk according to the European Atherosclerosis Society for adults,¹⁸ while the acceptable ratio of high density lipoprotein cholesterol: total cholesterol was set at 0.18 or above.¹⁸ Acceptable body fat percentages were fixed at less than 20% and 30% of total body mass for boys and girls respectively.¹⁹ Cardiorespiratory fitness thresholds were expressed as maximal oxygen uptake ($\dot{V}O_2$ MAX), and were set at 47 and 36 ml/kg/min for the older boys and girls respectively. These thresholds corresponded to the 25th centiles of the scores recorded for the 20-MST. Those children in the lowest of the four physical activity groups were considered to be 'at risk', as were those who admitted to smoking at least one cigarette per week. The occurrence of weekly smoking is

Table 1 Subject characteristics. Figures are mean (SD) unless otherwise stated

	Boys		Girls	
	12 years	15 years	12 years	15 years
Sample size	251	252	258	254
Age (years)	12.5 (0.3)	15.5 (0.3)	12.5 (0.3)	15.5 (0.3)
Height (cm)	150 (7.9)	169 (7.2)	151 (7.5)	161 (5.9)
Weight (kg)	43 (9.4)	59 (9.4)	44 (9.0)	57 (8.5)
Body composition (% fat)	19.3 (5.6)	18.4 (4.5)	25.7 (4.1)	28.0 (3.8)
Total cholesterol (mmol/l)	4.58 (0.82)	4.23 (0.73)	4.72 (0.77)	4.60 (0.77)
HDL cholesterol (mmol/l)	1.39 (0.31)	1.25 (0.25)	1.37 (0.29)	1.35 (0.27)
HDL cholesterol: total cholesterol	0.31 (0.07)	0.30 (0.08)	0.30 (0.07)	0.30 (0.07)
Smoking (%)	3	21	2	16
Predicted $\dot{V}O_2$ MAX (ml/kg/min)	45 (3.4)	51 (3.8)	40 (3.2)	40 (3.4)
Blood pressure (mm Hg):				
Systolic	111 (12)	123 (12)	112 (12)	118 (12)
Diastolic	68 (9)	73 (9)	71 (9)	74 (9)
Sexual maturity:*				
I	73	3	23	—
II	14	6	24	—
III	8	6	25	1
IV	2	14	8	2
V	2	71	21	97

HDL=high density lipoprotein.

*After Tanner 1962.⁸

Table 2 Individual risk factor results (% of population considered at risk for boys and girls with 95% confidence intervals in parentheses)

Threshold of risk*	Boys		Girls	
	12 years	15 years	12 years	15 years
Sample size	251	252	258	254
Systolic blood pressure at 12 years ≥ 126 and 15 years ≥ 136 mm Hg	11.2 (7.3 to 15.1)	16.3 (11.7 to 20.9)	11.3 (7.4 to 15.2)	8.3 (4.9 to 11.7)
Diastolic blood pressure at 12 years ≥ 82 and 15 years ≥ 86 mm Hg	7.3 (4.1 to 10.5)	10.8 (7.0 to 14.6)	11.0 (7.2 to 14.8)	11.0 (7.2 to 14.8)
One or both blood pressures raised	14.9 (10.5 to 19.3)	23.5 (18.3 to 28.7)	18.1 (13.4 to 22.8)	14.2 (9.9 to 18.5)
Total cholesterol > 5.2 mmol/l	20.0 (15.0 to 25.0)	10.3 (6.5 to 14.1)	23.4 (18.2 to 28.6)	18.9 (14.1 to 23.7)
HDL: total cholesterol < 0.18	4.0 (1.6 to 6.4)	4.8 (2.2 to 7.4)	2.7 (0.7 to 4.7)	0.8 (0.0 to 1.9)
High cholesterol or low HDL	20.8 (15.8 to 25.8)	11.5 (7.6 to 15.4)	24.5 (19.0 to 29.4)	18.9 (14.1 to 23.7)
Body composition (% body fat) for boys $> 20\%$ and girls $> 30\%$	33.5 (27.7 to 39.3)	23.8 (18.5 to 29.1)	17.8 (13.1 to 22.5)	29.9 (24.3 to 35.5)
Predicted $\text{VO}_2 \text{ MAX}$ (ml/kg/min) at 12 years: boys < 41 , girls < 36 ; at 15 years: boys < 47 , girls < 37	22.5 (17.2 to 27.8)	25.6 (20.2 to 31.0)	25.6 (20.3 to 30.9)	29.5 (23.9 to 35.1)
Physical activity (class 1 of four activity classes)	26.3 (20.9 to 31.7)	24.2 (18.9 to 29.5)	30.6 (25.0 to 36.2)	28.7 (23.1 to 34.3)
Smoking ≥ 1 cigarette/week	3.2 (1.0 to 5.4)	20.7 (15.7 to 25.7)	1.6 (0.1 to 3.1)	16.2 (11.7 to 20.7)
Positive family history	32.3 (26.5 to 38.1)	27.4 (21.9 to 32.9)	31.0 (25.4 to 36.6)	26.4 (21.0 to 31.8)

HDL=high density lipoprotein.

*See subjects and methods for determination of coronary risk thresholds.

indicative of adult smoking and consequential health problems.²⁰ A family history of cardiovascular disease (CVD), evaluated by parental questionnaire, was accepted as a risk factor where a cardiovascular event (heart attack, angina, stroke) occurred in (i) either parent at any age or (ii) a first degree relative under the age of 55, of either parent.

Results

The physical characteristics of the boys and girls in this study are given in table 1. The magnitude of the differences between the sexes and of the changes associated with growth were generally as expected for growing children.⁵

Individual risk factor results are shown in table 2. Between 14–24% of the children were hypertensive, 11–24% exceeded the acceptable limits for serum lipid values, and between 16–24% of the older children admitted to being regular smokers. Large proportions of children were also designated at risk due to excessive body fat (18–34%), lack of physical activity (24–31%), and poor cardiorespiratory fitness (23–30%). Between 26% and 32% had a positive family history of CVD.

Selected dietary measures, which are considered as possible indicators for the risk of CHD, are given in table 3. Energy intakes tended to be higher in the 15 year old boys group compared with the 12 year old boys. Girls did not show age related differences in energy intake. Similar results were obtained when

Table 4 Combined risk factor incidence by age and sex as percentage

	No of factors children at risk in					
	≥ 1	≥ 2	≥ 3	≥ 4	≥ 5	6
Boys:						
12 years (n=251)	62.9	35.1	17.1	4.4	0.4	0
15 years (n=252)	69.4	37.3	15.9	4.8	1.2	0.4
Girls:						
12 years (n=258)	69.0	32.9	11.2	3.5	0.8	0
15 years (n=254)	74.4	41.7	16.5	4.3	0.4	0

Risk factors considered were blood pressure, cholesterol, body composition, predicted $\text{VO}_2 \text{ MAX}$, physical activity, and smoking, as specified in table 2.

intakes of total fat, sugars, and dietary fibre were compared. However there were no significant differences between age groups when fat (or sugars) intakes were expressed as a percentage of energy intakes. The dietary ratio of polyunsaturated to saturated (P:S) fatty acids was significantly lower in 12 year old boys than in girls of the same age ($p < 0.01$); in the older children, boys also had a significantly lower P:S ratio than girls ($p < 0.001$). Similar conclusions were drawn when the above comparisons were performed on the edited sample. Comparisons between groups were based on the Kolmogorov-Smirnov two sample test at a 5% significance level.

Table 4 describes the proportion of children exhibiting multiple risk factors considered to be modifiable that is, excluding family history.

Discussion

At the onset of the present study, no comprehensive information was available on the nature and extent of factors associated with coronary risk in the childhood population of Northern Ireland or elsewhere in the UK. Such information is important to help formulate and evaluate primary prevention strategies aimed at children, particularly in a region of such high CHD mortality. The levels of coronary risk displayed by the subjects in the present study must be interpreted with care. Despite several attempts to standardise paediatric risk thresholds,^{19, 21} the process remains essentially intuitive and arbitrary. Nevertheless, accumulating evidence

Table 3 Mean (SD) energy and selected dietary intakes

	Boys		Girls	
	12 years	15 years	12 years	15 years
Sample size	251	252	258	254
Energy (MJ/day)	11.68 (3.35)	13.58 (3.62)	9.60 (2.67)	9.55 (2.75)
Energy (MJ/day)*	10.69 (1.90)	13.12 (2.03)	9.62 (1.65)	10.10 (1.85)
Total sugars (g/day)	152 (62)	171 (65)	128 (49)	125 (51)
Dietary fibre (g/day)	21.3 (7.7)	24.3 (7.9)	19.0 (6.3)	19.6 (6.7)
Total fat (g/day)	123 (39)	142 (43)	101 (33)	101 (34)
Fat as a % of energy	39.8 (4.4)	39.6 (4.5)	39.8 (4.7)	40.0 (4.7)
P:S ratio	0.22 (0.14)	0.25 (0.19)	0.26 (0.16)	0.28 (0.16)

*Edited sample consists of those subjects such that daily energy intake to basal metabolic rate ratio was > 1.3 and < 2.5 ; at 12 years: boys n=171, girls n=190; at 15 years: boys n=191, girls n=175.

from longitudinal studies^{22 23} vindicate the early identification of risk in children, particularly for body fat percentage, blood lipids, hypertension, cigarette smoking and cardiorespiratory fitness, all of which appear to track with age. Furthermore, habitual physical activity has been shown to be significantly related to other risk factors in children.²⁴ These findings may be of particular relevance to the children of Northern Ireland, in whom high levels of risk for body composition, blood lipids, cigarette smoking, cardiorespiratory fitness and physical activity, were evident.

Obesity is now well established as an independent risk factor for CHD in adults.²⁵ Although skinfold thickness were comparable with other British children of similar age,²⁶ they were considerably higher than other northern European countries, for example Finland²³ and Holland.⁶ The mean energy intakes of the present subjects were considerably higher than the estimated average requirements for energy (9.27 and 7.92 MJ; 11.51 and 8.83 MJ for boys and girls aged 11–14 years and 15–18 years respectively) published recently by the Committee on Medical Aspects of Food Policy (COMA) for the UK.²⁷ The figures for estimated average requirements were based on estimates of energy expenditure for boys weighing 39 and 57 kg and girls weighing 41 and 53 kg aged 12 and 15 years respectively. Even allowing for the higher body weights of boys and girls of these ages in Northern Ireland (table 1), their reported intakes would indicate either much higher physical activity levels, or inappropriately high energy intakes compared with their reference counterparts in the COMA report.²⁷

Diet may be implicated in the unfavourable serum lipid profiles revealed for Northern Ireland schoolchildren, compared with their Dutch,⁶ North American,² and Italian counterparts,²⁸ all of whom reported lower dietary fat intakes. Similarly, P:S ratios in the above quoted studies were all substantially higher than those reported here. Although methodological differences make comparisons of dietary intakes between studies difficult, these results indicate that the diet of Northern Ireland schoolchildren is clearly a cause for concern.

Blood pressure values were higher than those previously recorded in British schoolchildren and were abnormally high in one in six children studied. These results, while based on measurements on only one occasion, were strongly influenced by body size and fat, emphasising the importance of maintaining ideal body weight in the prevention of hypertension. The evidence that this unhealthy relationship is already established in children is also a major cause for concern. There was a tendency toward lower systolic blood pressure with increasing birth weight in keeping with suggestions that intrauterine environment can influence blood pressure in later life.

Cardiorespiratory fitness has been associated with coronary risk in both adults²⁹ and children.^{30 31} Various arbitrary thresholds of aerobic power ($\dot{V}O_2$ MAX) indicative of healthy cardiorespiratory systems have been suggested for children.^{19 32} In the present study, levels of cardiorespiratory fitness based on the 25th

centiles for scores in the 20-MST, were used as thresholds of risk. When converted to predicted maximal oxygen uptake, these resulted in scores of 46.7 and 36.4 ml/kg/min for 15 year old boys and girls respectively. These thresholds would appear to concur with suggested minimal levels for adult men and women (42 and 35 ml/kg/min respectively),³³ given an approximate 10–15% decline in cardiorespiratory fitness between adolescence and early adulthood.³⁴ On this basis, a large proportion of 15 year old boys, and the vast majority of 15 year old girls in the present study, are not fit enough for optimal health.

A sedentary lifestyle in adults is an established risk factor for CHD.³⁵ Results of the present study corroborate evidence for the sedentary lifestyle of British schoolchildren,³⁶ and justify concern about the long term health implications of such behaviour. This is particularly so given the demonstrated inter-relationships between physical activity and other CHD risk indicators in children²⁴ and the role of increased exercise in the reduction of such measures in paediatric populations.³⁷ Clearly the concept of regular exercise for health must be communicated more effectively to schoolchildren.

Smoking even one cigarette per week is accepted as constituting regular smoking in children.²⁰ Using this definition, the proportion of self reported smokers increased dramatically between 12 and 15 years of age, in keeping with previous reports.^{23 38–40} In the older age group more boys (21%) than girls (16%) were smokers. This is in contrast with studies that show that more girls than boys smoke, for example, in England (22 v 17% respectively) and also in Scotland and Wales (27 v 18%).⁴¹ The lower prevalence of Northern Irish girls smoking was noted previously in 1982 and 1986,^{42 43} and since then no substantial increase in the number of girls smoking has occurred. The undoubted trend towards higher smoking prevalence in girls in the UK and other countries^{3 41} will result in an epidemic of smoking related diseases in the current generation of girls as they grow older.

Antismoking strategies must target both sexes and should commence at primary school age and be sustained through secondary school and into the work place. New approaches need to be developed to enable children to counteract peer pressure and market forces to smoke. Numerous studies confirm that cigarette advertising clearly influences children.^{44–46} Two thirds of 9–10 year olds can name at least one cigarette brand³⁹ and many other children can identify cryptic cigarette advertisements.⁴⁷ The banning of cigarette advertising and sports sponsorship should be implemented without delay. Strong associations between children smoking and parental and sibling smoking mean that childhood antismoking strategies must be an integral part of a comprehensive health education programme aimed at reducing smoking at all ages in the community as a whole.

Given the high prevalence of CHD in Northern Ireland it is not surprising that a significant proportion of children (30%) have a positive family history. In table 4 we have chosen to

exclude family history from the evaluation of risk factor aggregation within individuals to highlight potentially modifiable risk behaviours. Despite this, a substantial proportion of children exhibit multiple risk factors so that at age 12 years, 14% are at risk in three or more categories rising to over 16% at age 15 years. The ability to identify this particular subgroup at an early age may present an opportunity for targeted intervention.

In conclusion, the results of this cross sectional study gives serious cause for concern about nascent coronary risk in the childhood population of Northern Ireland. Health educational and intervention strategies have until now generally been aimed at adults, in whom the atherosclerotic process is already advanced. The adoption of a healthy lifestyle and behaviour pattern must, however, be encouraged from an early age. Broadly based primary prevention strategies aimed at children, emphasising the importance of not smoking, a healthy diet, and regular exercise are imperative if future adult CHD mortality is to be reduced.

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