A three year study of coronary heart disease risk factors in Greek adolescents.

Original Research

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A Three Year Study of Coronary Heart Disease Risk Factors in Greek Adolescents

Constantin Bouziotas and Yiannis Koutedakis

We examined the prevalence of 14 modifiable CHD risk factors in a sample of 210 provincial Greek children as they progressed from age 12 to 14. It was found that 46.2% of boys and 49.5% of girls ($p > 0.05$) exhibited three or more risk factors at their 12th year, with values of 42% for boys and 51.1% ($p > 0.05$) for girls for their 13th year, and 29.4% for boys and 55% ($p < 0.001$) for girls in their 14th year. Risk factors with the highest prevalence in both sexes included low vigorous physical activity, low aerobic fitness, and elevated body fatness. The fact that boys exhibited progressively fewer risk factors with age was mainly attributed to increased time spent on vigorous physical activity ($P < 0.001$) and higher predicted oxygen intake ($P < 0.001$) with a concomitant decrease in body fat ($P < 0.001$). The opposite pattern demonstrated by girls was primarily due to elevated predicted % body fat ($P < 0.05$), % saturated fat intake ($P < 0.05$), total cholesterol (TC; $P < 0.001$), low-density lipoprotein cholesterol (LDL-C; $P < 0.001$), and decreased high-density lipoprotein cholesterol (HDL-C)/TC; $P < 0.001$). In conclusion, a high percentage of young adolescent Greek boys and girls exhibit three or more modifiable CHD risk factors. However, as the children progress from age 12 to 14, gender differences emerge regarding the development of their CHD risk profiles. The present data support the notion that preventive strategies for combating CHD should begin early in life.

Introduction

There is a growing conviction that atherosclerosis, the underlying pathology for coronary heart disease (CHD), can be a pediatric problem (5). Certain biological (e.g., obesity, poor aerobic fitness, and adverse lipid profile) and lifestyle parameters (e.g., hypo-activity, smoking, and atherogenic diet) that have been identified as potent risk factors for predicting future CHD in adults have also been detected in children and adolescent populations (28). Furthermore, the development of behaviors that are implicated in the pathogenesis of CHD have their origin in childhood and adolescence (14).

The authors are with the School of Sport, Performing Arts and Leisure, University of Wolverhampton, UK; Y. Koutedakis is also with the Department of Sports and Exercise Science, Thessaly University, Greece.

Previous studies have addressed the issue of prevalence of CHD risk factors in children and highlighted the importance of activity (22), aerobic fitness (9), and obesity (19,20) in relation to a beneficial CHD risk profile. However, studies of CHD risk factors in children are often conflicting and unclear (29,16).

In line with their European and North American counterparts, Greek children demonstrate decreased physical activity levels (18), increased prevalence of obesity (17), westernized nutritional habits (21), and adverse lipid profile (8). Furthermore, it has been found that a significant percentage of 12-year-olds exhibited more than three modifiable CHD risk factors (7). However, there is little epidemiological data on the persistence of modifiable CHD risk factors in Greek children over time. Therefore, the purpose of the present investigation was to examine whether the modifiable CHD risk factors already detected in 12-year-old Greek boys and girls do persist as the same children progressed to ages 13 and 14.

Methods

This study is part of a 6-year longitudinal study of CHD risk factors in a sample of 210 Greek pupils, which will be completed in 2003. The original baseline survey, which provides the basis for the current investigation, was completed in 1999 (7).

Subjects

The total of 210 boys and girls (mean age 12.3 years) volunteered from seven secondary schools of Katerini, Greece. The subjects were selected to have benign medical histories. The boys (1st yr, $n = 117$; 2nd yr, $n = 112$; 3rd yr, $n = 109$) and the girls (1st yr $n = 93$; 2nd yr $n = 92$; 3rd yr $n = 89$) participated in a 3-year screening program for 14 modifiable CHD risk factors. The Research Ethics Committee of the University of Wolverhampton, UK, approved the investigation and permission was granted from the Greek Ministry of Education. In addition, written informed consent was obtained from the subjects and their parents after full explanation of the experimental procedures.

Data Collection

The methodology and the criteria used for the purpose of this study have been described elsewhere (7). Specifically, all pupils were subjected to anthropometric, physical activity, cardiorespiratory fitness, selected dietary intake, smoking status, serum lipid and blood pressure assessments. Measurements were conducted at the beginning of each school year by the same investigators for three consecutive years. Data were compared to published criteria thresholds for the 14 modifiable CHD risk factors (Table 1) in each of the 3 years of the study. A brief description of the above measurements follows.

Anthropometric measurements. These included age (accurate to 1 month), height (measured to the nearest 0.5 cm), and weight (recorded to the nearest 0.5 kg). Percentage body fat was calculated from two skinfolds measurements (triceps and medial calf) with a Harpenden calliper using the Lohman's (15) formula.

Physical activity assessment. Aaron et al.'s (1) physical activity recall questionnaire and a tailor-made lifestyle questionnaire were utilized. The metabolic cost of

each activity obtained from both questionnaires was used to calculate the time spent in daily moderate-to-vigorous (>3 & < 6 METs) and vigorous (>6 METs) physical activity (2).

Cardiorespiratory fitness assessment. Using the shuttle run test (13), subjects performed a series of runs across a 20-m track, changing direction at the end of each run to coincide with an audio signal, which gets progressively faster. Maximal oxygen intake (VO_2max) in ml/min/kg was then predicted from the level at which subjects ceased exercise.

Selected dietary intakes assessment. Information on the food intake of the subjects was collected with their parent's assistance by means of a 7-day dietary diary. Using the Food Composition Tables for Greek food (27), total and saturated fat intake was estimated and expressed as percentage of total energy intake.

Smoking status assessment. Subjects who smoked one or more cigarettes per week were considered as smokers.

Serum lipids. Approximately 5 ml of venous blood was taken from the antecubital vein under local anesthesia (xylocaine) from each subject with a vacutainer following an overnight fast. A Technicon R-XT autoanalyzer was utilized for determination of serum lipids and lipoproteins. External quality control took place with samples from the National System of External Evaluation of Quality of the Results in Clinical Chemistry in Athens, Greece.

Blood pressure recording. A mercury sphygmomanometer was used. The mean of two measurements of Korotkoff phase I was recorded for systolic blood pressure. The mean of two values of Korotkoff Phase IV was recorded for diastolic blood pressure.

Criteria thresholds for CHD risk. Cut-off values for the 14 modifiable CHD risk factors used in this study appear in Table 1. These published thresholds, however, are for children 12–16 years of age and do not take into account developmental processes. The latter may present an inherited limitation.

Statistical Analyses

The Chi-square test was used to compare the percentages of boys and girls exhibiting three or more CHD risk factors in each year of the study. Cochran's Q test was adopted to detect relative changes in boys and girls exhibiting three or more CHD risk factors during the whole study period. This was conducted together with the *post-hoc* McNemar multiple comparison test.

Results

The threshold criteria for the 14 CHD risk factors appear in Table 1. The subjects' anthropometric characteristics are depicted in Table 2. Tables 3 and 4 describe percentages of boys and girls being "at risk" according to set criteria associated with the 14 studied CHD risk factors. It is worth noting that, during the 3-year study, a considerable percentage of boys were "at risk" for developing CHD primarily because of low aerobic fitness, elevated body fatness, and reduced vigorous physical activity. In addition to these, blood lipid profiles (TC, LDL-C and HDL/TC) were also among those parameters contributing to the girls' "at risk"

Table 1 Criteria Thresholds for the 14 Selected Modifiable CHD Risk Factors in Children According to Literature

Variable		Risk factors
Body fat (%)	Boys	>20%
	Girls	>30%
Physical activity (hours/day)		<1 hour/day of ≥3 - <6 METs <0.5 hour/day of ≥6 METs
Cardiorespiratory fitness (Predicted VO_2max in ml/min/kg)	Boys	<34
	Girls	<29
Dietary fat in relation to total energy intake (%)		>30%
Saturated fat in relation to total energy intake (%)		>10%
Smoking (cigarettes per week)		≥1
TC (mg/dl)		≥200
LDL-C (mg/dl)		≥130
HDL-C (mg/dl)		≤30
TG (mg/dl)		≥150
HDL-C/TC		≤0.18
Systolic blood pressure (mm Hg)		≥134
Diastolic blood pressure (mm Hg)		≥90

Note. Modified from Bouziotas et al. (7)

Table 2 Anthropometric Characteristics of Boys and Girls During the Study Period

		12-years	13-years	14-years
		Boys (n = 117) Girls (n = 93)	Boys (n = 112) Girls (n = 92)	Boys (n = 109) Girls (n = 89)
Age (years)	Boys	12.3 (±0.6)	13.3 (±0.6)	14.2 (±0.5)
	Girls	12.3 (±0.6)	13.3 (±0.6)	14.3 (±0.5)
Height (cm)	Boys	153.4 (±7.9)	160.0 (±8.7)	167.7 (±8.3)
	Girls	153.5 (±6.2)	156.8 (±5.9)	158.2 (±11.9)
Weight (kg)	Boys	47.7 (±10.0)	54.4 (±11.3)	61.4 (±11.9)
	Girls	47.4 (±9.8)	51.3 (±9.8)	54.1 (±9.1)

Note. Values are Means (±SD)

Table 3 Percentage (%) of Boys Exhibiting "At-Risk" Profile for CHD, Based on Set Criteria Thresholds for 14 Modifiable CHD Risk Parameters, During Their 12th, 13th, and 14th Year of Age

CHD risk parameters	At risk		
	12th year (n = 117)	13th year (n = 112)	14th year (n = 109)
Predicted %body fat	52	39	32
Physical activity ≥6METs (hours/day)*	54	38	30
Physical activity ≥3METs - <6METs (hours/day)**	2	0	0
Predicted VO_2 max (ml/min/kg)	54	14	26
%Dietary fat intake (of total energy intake)	8	12	7
%Saturated fat (of total energy intake)	33	39	35
Smoking (cigarettes per week)	4	3	11
TC (mg/dl)	6	14	13
LDL-C (mg/dl)	8	24	17
HDL-C (mg/dl)	0	1	0
TG (mg/dl)	0	5	2
HDL-C/TC	0	6	2
Systolic blood pressure (mm Hg)	0	1	0
Diastolic blood pressure (mm Hg)	0	0	1

*Mean of hours per day spent on vigorous (≥6METs) physical activity.
**Mean of hours per day spent on moderate to vigorous (≥3METs - <6METS) physical activity.

profile. Smoking, HDL-C, triglycerides (TG), systolic (SBP), and diastolic (DBP) blood pressure were the least frequent risk factors in both sexes.

Figure 1 illustrates the percentages of boys and girls exhibiting three or more CHD risk factors in each year of the study. Chi-square test revealed that 46.2% of boys and 49.5% of girls ($P > 0.05$) matched the set criteria in the first year, with the corresponding values for the second and third years to be 42% and 51.1% ($P > 0.05$) and 29.4% and 55% ($x^2_1 = 13.87$, $P < 0.001$), respectively. Cochran's Q test revealed a statistically significant decline in the percentage of boys exhibiting three or more CHD risk factors during the study period (Cochran's $Q = 14.97$, $P < 0.001$). However, the apparent increases in the percentages of girls presenting three or more CHD risk factors during the same period were found to be not significant ($P > 0.05$). In boys, the McNemar post-hoc test revealed statistically significant differences between first and third ($P < 0.001$) and second and third ($P < 0.01$) years.

Cochran's Q tests also revealed that the fact that boys were exhibiting progressively fewer risk factors was mainly attributed to increased time spent on vigorous physical activity ($P < 0.001$) and enhanced predicted oxygen intake ($P < 0.001$) with a concomitant decrease in body fat ($P < 0.001$). The opposite pattern

Table 4 Percentage (%) of Girls Exhibiting "At-Risk" Profile for CHD, Based on Set Criteria Thresholds for 14 Modifiable CHD Risk Parameters, During Their 12th, 13th and 14th Year of Age

CHD risk parameters	At risk		
	12th year (n = 117)	13th year (n = 112)	14th year (n = 109)
Predicted %body fat	19	17	26
Physical activity ≥6METs (hours/day)*	76	71	76
Physical activity ≥3METs - <6METS (hours/day)**	5	1	6
Predicted VO_2max (ml/min/kg)	52	44	46
%Dietary fat intake (of total energy intake)	23	14	12
%Saturated fat (of total energy intake)	49	40	37
Smoking (cigarettes per week)	2	2	1
TC (mg/dl)	4	36	25
LDL-C (mg/dl)	5	36	28
HDL-C (mg/dl)	3	2	0
TG (mg/dl)	1	3	0
HDL-C/TC	2	10	2
Systolic blood pressure (mm Hg)	0	1	1
Diastolic blood pressure (mm Hg)	0	1	0

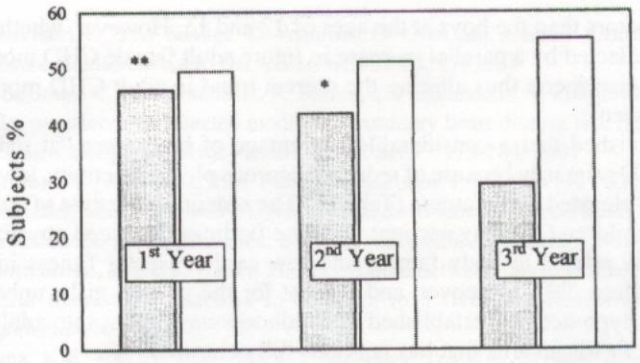
*Mean of hours per day spent on vigorous (≥6METs) physical activity.
**Mean of hours per day spent on moderate to vigorous (≥3METs - <6METS) physical activity.

demonstrated by girls was primarily due to elevated predicted % body fat ($P < 0.05$), % saturated fat intake ($P < 0.05$), TC ($P < 0.001$), LDL-C ($P < 0.001$) and decreased HDL-C/TC ($P < 0.001$).

Discussion

Identification of individuals with relatively high CHD risk profiles may allow for an early and effective application of prevention strategies. However, the etiology of CHD is multi-factorial, and no single risk factor can necessarily result in the development of clinical symptoms. The more risk factors present, the greater the risk. A 35-year-old man has a probability of 0.3/100 with one risk factor and 11.3/100 with three risk factors of developing CHD within 6 years (31).

The main finding of the present study was that 46.2% of boys and 49.5% of girls exhibited three or more CHD risk factors at their 12th year, with the corresponding values for their 13th and 14th years to be 42% and 51.1% and 29.4% and 55%, respectively (Figure 1). These findings were rather surprising considering the recent history of CHD in Greece. Until the 1960s and 70s, Greek adults suffered relatively little from CHD compared with their American or European



1st Year (χ^2 test) : **P>0.05 between boys and girls**
2nd Year (χ^2 test) : **P>0.05 between boys and girls**
3rd Year (χ^2 test) : **P<0.001 between boys and girls**
Cochrans' Q test : **P<0.001 decline in boys exhibiting three or more CHD risk factors during the study period. P>0.05 for girls.**
McNemar post-hoc test : **** Boys 1st and 3rd year (P<0.001)**
*** Boys 2nd and 3rd year (P<0.01)**

Figure 1 — Percentages of subjects exhibiting three or more risk factors during the study period.

counterparts (12). However, recent studies have indicated that Greek adults are exhibiting an upward trend in the development of the disease (11). Obesity (17), reduced physical activity, heavy smoking, and increased serum TC (30) are among the most frequently found CHD risk factors in Greek adults. We found that the same risk factors are also present in children. It could be argued, therefore, that the relatively recent upward trend in CHD mortality in the Greek adult population is already reflected by increased risk status at much younger ages.

Figure 1 also reveals a gender specific pattern concerning the percentage of boys and girls exhibiting three or more CHD risk factors. Throughout the 3-year study, progressively fewer boys demonstrated three or more CHD risk factors compared to girls. The steady decline of boys being "at risk" was mainly attributed to increased time spent on vigorous physical activity and an improved predicted oxygen intake with a concomitant decrease in body fat. This finding is in line with published data showing that boys are more active than girls (10) and that boys' aerobic fitness is greater compared to girls' (4). Differences between boys and girls in muscle mass and hemoglobin concentration (3) as well as increases in adipose tissue in females approaching menarche (23) may account for the latter.

Although direct comparisons with other studies are difficult, the above findings contradict the Bogalusa Heart Study whereby boys rather than girls showed the greatest percentage of multiple CHD risk factors (31). In contrast, there is an agreement with a more recent set of data (6) where girls exhibited higher percentages

of CHD risk factors than the boys at the ages of 12 and 15. However, whether the latter will be reflected by a parallel increase in future adult female CHD mortality in Greece and elsewhere, thus altering the current trend in adult CHD mortality, remains to be seen.

We established that a considerable percentage of boys were "at risk" for developing CHD primarily because of reduced vigorous physical activity, low aerobic fitness, and elevated body fatness (Table 3). The sedentary lifestyle of contemporary Greek children (18) may account for these findings. Reduced physical activity is directly related to body fatness and low cardiovascular fitness in both adults and children (29). Moreover, and at least for the present girls, unhealthy habits, such as hypo-activity, established in childhood may persist into adulthood (26). However, this is an area that has not been fully clarified.

We further found that, apart from reduced vigorous physical activity, low aerobic fitness, increased saturated fat intake, and elevated body fatness identified in boys, parameters associated with blood lipid profile (TC, LDL-C and HDL-C/TC) were among those contributing to the girls' "at risk" profile (Table 4). This gender difference, also seen in other studies (25), may be due to hormonal changes associated with sexual maturation processes, which appear to influence the divergence of lipoprotein serum concentrations between boys and girls (24). Hormonal changes may also explain the noticeable increase in the prevalence of certain blood lipid parameters in girls as they progressed from the age of 12 to 13. For instance, decrease in estradiol and increase in progesterone levels in girls favor high LDL-C concentrations in plasma.

In conclusion, a high proportion of Greek children demonstrate three or more CHD risk factors. However, as the children progress from age 12 to 14, gender differences can be detected regarding the development of their CHD risk profiles. Within the study's limitations, the findings of the present study proclaim that primary prevention strategies for CHD risk should start in early childhood, if future Greek adult CHD mortality is to be controlled. Specific CHD risk thresholds for the different developmental stages during childhood should be examined in future studies.

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