Greek adolescents, fitness, fatness, fat intake, activity, and coronary heart disease risk

C Bouziotas, Y Koutedakis, A Nevill, E Ageli, N Tsigilis, A Nikolaou, A Nakou

Background: A dramatic increase in adult mortality rates from coronary heart disease (CHD) in Greece, accompanied by increased prevalence of CHD risk factors in children, has been documented. However, there is controversy about the independent effects of certain lifestyle parameters on primary CHD risk factors.

Aims and Methods: To examine the association between CHD risk factors (HDL-C, LDL-C, HDL-C/TC, triglycerides, systolic and diastolic blood pressure) and lifestyle parameters (fitness, fatness, fat intake, and physical activity) in 210 12-year old Greek pupils.

Results: Correcting for the fixed factors of gender and maturation, analyses of covariance (ANCOVA) with backward elimination of the lifestyle covariates revealed significant associations between three CHD risk factors (HDL-C, HDL-C/TC, systolic blood pressure) and physical activity levels. In contrast, the covariates aerobic fitness, fatness and fat intake failed to reach significance with any of the CHD risk factors.

Conclusions: In Greek schoolchildren, primary CHD risk factors are mainly associated with physical activity levels, independently of fitness, fatness, and/or fat intake. Prevention strategies should concentrate on enhancing physical activity early in life, if the increased prevalence of Greek adult CHD mortality is to be diminished.

Subjects
The population studied consisted of 210 healthy subjects (117 males and 93 females, mean age 12.3, SD 0.6 years). They volunteered from all seven secondary schools in the town of Katerini (~50 000 inhabitants), Greece. All measures of anthropometry, aerobic fitness, and physical activity were conducted in the school environment (during PE classes), at the beginning of the school year and by the same experienced investigator (the principal author), using the same order of testing procedures. Blood samples and blood pressure data were obtained at the local state hospital by three medical practitioners and nurses. Written informed consent was acquired from all subjects and their parents after full explanation of data collection procedures. The Research Ethics Committee of the University of Wolverhampton approved the investigation and permission was granted from the Greek Ministry of Education.

Data collection
Anthropometry
Weight was measured to the nearest 0.5 kg (Seca beam balance 710) with subjects being lightly dressed and barefooted, and standing height was measured to the nearest 0.5 cm (Seca stadiometer 208). Percentage body fat (defined as “fatness”) was calculated according to published guidelines, that is, from triceps and medial calf skinfold measures (average of two measurements of each site) using a Harpenden (John Bull, UK) calliper.

Sexual maturity
Assisted by a female medical doctor who specialised in paediatric medicine, sexual maturity status was assessed by

Abbreviations: CHD, coronary heart disease; HDL, high density lipoprotein; LDL, low density lipoprotein; TC, total cholesterol; TG, triglycerides
self evaluation, according to Tanner’s\textsuperscript{17} criteria for breast, pubic hair, and genital development. It has been suggested that this is the most appropriate method for general application in evaluation of maturity status.\textsuperscript{18}

**Aerobic fitness**

Defined as the maximal oxygen uptake ($\text{VO}_2\text{max}$), or the greatest rate at which oxygen can be taken in during exercise, aerobic fitness was assessed using the children’s validated 20 metre shuttle run test.\textsuperscript{19} Subjects had to run back and forth between two lines set 20 metres apart. Running pace was determined by audio signals, emitted from a pre-recorded cassette tape, with the initial velocity being 8.5 km/h. Running speed was increased at regular intervals of 0.5 km/h every minute. The test was terminated when children failed to reach the lines concurrent with the audio signals on two consecutive occasions. $\text{VO}_2\text{max}$ was then predicted from the number of “laps” completed.\textsuperscript{20}

**Fat intake**

Information on dietary fat intake was obtained by means of a seven day dietary diary. Photographs illustrating portion sizes of the most commonly consumed food items and beverages were used while keeping the diaries. Both pupils and their parents were instructed on how to keep a record of the amount and type of food and beverages consumed on seven consecutive days. After collection, each diary was checked by the principal investigator and the child involved to ensure accuracy of the recorded information. Using the Food Composition Tables for Greek food,\textsuperscript{21} fat intake was estimated and expressed as percentage of total energy intake.

**Physical activity**

For the assessment of physical activity levels,\textsuperscript{22} the Past Year Physical Activity Recall Questionnaire of Aaron\textsuperscript{23} was utilised. This questionnaire has been shown to yield reproducible and valid estimates of past year physical activity in adolescents aged 12–17 years. Briefly, subjects were asked to indicate all organised physical activities as a member of any sports club, including school PE, and all leisure time physical activities (for example, walking, cycling, stair climbing, etc) in which they participated during the past year. They also had to give detailed information regarding the frequency and duration of each individual activity. The metabolic cost of each activity\textsuperscript{24} was then used to calculate a total physical activity score expressed in kcal per kg per day.

**CHD biological risk factors; determination of lipid and blood pressure profiles**

Procedures have been described in detail elsewhere.\textsuperscript{12} Briefly, after an overnight fast, approximately 5 ml of blood was taken from each child with a vacutainer, for lipid and lipoprotein analyses using a Technicon R-XT autoanalyser. Serum total cholesterol (TC) and TG were determined by automated enzymatic techniques (CHOD-PAP, Boehringer Mannheim GmbH, Germany and CPO-PAP-method, Boehringer Mannheim GmbH, Germany) respectively. Serum HDL-C concentration was measured in the supernatant after precipitation of very low density and low density lipoproteins with phosphotungstic acid (Boehringer Mannheim Kit). Low density lipoprotein cholesterol (LDL-C) concentration was calculated according to the formula of Friedewald and colleagues.\textsuperscript{25}

Blood pressure was measured using a standard mercury sphygmomanometer after the child had been sitting quietly for five minutes. 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.\textsuperscript{25}

**Statistical analysis**

The $\chi^2$ test was used to examine whether there was a difference in the percentages of boys and girls participating in the present investigation. Preliminary evaluation of the variables using a Kolmogorov-Smirnov test of normality revealed that three variables (body fat, LDL-C, and TG) required logarithmic transformation in order to reach normality. Means (SD) were calculated for all parameters.

Pearson’s product moment correlation coefficients were computed to assess relations among fitness, fatness (percentage body fat), and physical activity. A linear model was used to examine possible associations between each of the CHD risk factors and fitness, fatness, fat intake, and physical activity. Specifically, analyses of covariance with backwards elimination of the lifestyle covariates were used to investigate the effects of gender and maturation (as fixed factors) on each of the CHD risk factors (dependent variable), using fitness, fatness, fat intake, and physical activity as covariates. The level of statistical significance was set at $p<0.05$.

**RESULTS**

Fifty six per cent of the present subjects were males and 44% were females. $\chi^2$ analysis revealed that there was no significant difference in the percentages of male and female participants ($\chi^2 = 2.74, p = 0.098$).

Table 1 presents descriptive data for all studied parameters. Apart from percentage body fat, which was higher, all other parameters were lower than internationally proposed cut-off points of selected CHD risk indicators in children.\textsuperscript{26}

Table 2 shows the Pearson’s product moment correlation coefficients among fitness, fatness, and physical activity. All these parameters were found to be modestly correlated at $p<0.01$.

Analyses of covariance revealed that, compared to lifestyle parameters of fitness, fatness, fat intake, and physical activity, only physical activity was significantly associated with selected CHD risk factors. Specifically, physical activity was associated positively with HDL-C ($p<0.001$) and HDL-C/TC ($p<0.001$), and negatively with systolic blood pressure ($p<0.001$).

**DISCUSSION**

Over the past 30 years, increased mortality rates from CHD have been observed in Greek adults.\textsuperscript{27} This upward trend is reflected by lifestyle changes\textsuperscript{28–29} and a high prevalence of CHD risk factors in Greek children.\textsuperscript{12}\textsuperscript{13} However, the independent contribution of lifestyle parameters (for example, fitness, fatness, diet, and habitual physical activity levels)
on primary CHD risk factors (for example, blood lipids and blood pressure) remains unclear. The purpose of this study was to further explore this issue focusing on Greek children.

We found associations between physical activity and CHD risk factors to be stronger than between fatness, fitness, and fat intake and the same CHD risk factors. Specifically, correcting for the fixed factors of gender and maturation, analyses of covariance with backward elimination of the lifestyle covariates revealed three significant associations between the CHD risk factors (HDL-C, HDL-C/TC, and systolic blood pressure) and physical activity levels. In contrast, the covariates aerobic fitness, fatness, and fat intake failed to reach significance with any of the CHD risk factors. We did not find any associations between LDL-C, TG, diastolic blood pressure, and the lifestyle parameters, which may be attributed to genetic and metabolic factors and/or to low baseline values. In general, these findings suggest that physical activity is the most significant lifestyle predictor for CHD risk factors in Greek children. This is despite the fact that our subjects revealed lower physical activity levels (45 kcal/kg/day) than those previously reported for other paediatric populations (58 kcal/kg/day). Nevertheless, as young people assume responsibility for their own health related behaviour and attitudes, the present findings may be particularly useful to health promotion strategists.

The present study complements previous reports showing strong associations between inadequate levels of physical activity and the atherogenicity of high lipid levels and raised blood pressure. Our data are also in line with a comprehensive recent review where aerobic fitness appeared not to be related to plasma lipids or lipoproteins. The fact that a strong association between inadequate levels of physical activity and the atherogenicity of high lipid levels and raised blood pressure.

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of correlational studies is difficult because of differences in subject characteristics (including social and cultural backgrounds), in methods employed to assess fitness related parameters, and in statistical techniques employed to analyse multivariate data.

It is noteworthy that the present data contradict recent reports citing obesity as the single most important contributor in the pathogenesis of CHD during childhood. Part of the explanation for this discrepancy may be that fitness, fatness, and physical activity levels are interrelated, which has likewise been established by the present data. Although not directly monitored, social and cultural differences between the children studied may also account for the observed discrepancies.

Confirming a previous report in Greek children, we found that the CHD risk factors studied were not substantially affected by qualitative aspects of diet. The relatively low baseline data found in the present study and/or the methodology used may account for this. For instance, the mean dietary fat intake of 25% of the total energy intake was lower than the 30% recommended for children of this age group.

In conclusion, and within the study's limitations, primary CHD risk factors in Greek schoolchildren are mainly associated with physical activity levels, independent of fitness, fatness, and/or fat intake. As reduced activity is a well-established CHD risk factor in adults, concern about the long term health implications in children is justified. CHD primary preventive strategies should aim at effective habitual physical activity interventions if the future CHD risk of the Greek population is to be reduced.

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