Lipid profiles, anthropometry and dietary habits of adolescent school boys in Sri Lanka

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Serum lipid profiles, anthropometric parameters, dietary habits and smoking practice were determined in 637 adolescent school boys in the 10th to 13th year of school (mean age 16.7 ± 1.3 years), to determine the prevalence of risk factors for cardiovascular disease in later life. They all attended schools in Colombo, the capital city (n=416), and two other cities, Negombo and Kurunegala. Seven percent of the subjects had body mass index (BMI) values above a reference range (for age 14-16, > 23.5 kg/m^2; older than 16 years > 24.5 kg/m^2). The mean serum total cholesterol concentration was within the reference range (158.9±27.2 mg/dL: 4.11±0.70 mmol/L), but 16.5% had values >185 mg/dL. The percentages of subjects with high LDL (low density lipoprotein)cholesterol (>110 mg/dL) and apolipoprotein B (>85 mg/dL) concentrations were 21.9 % and 23.0% respectively, while low HDL (high density lipoprotein) cholesterol (<35 mg/dL) levels were noted in 27.3% of subjects. A significant ($p<0.001$) positive association was noted between serum total cholesterol concentration and BMI. There was no significant difference in the mean BMI or total cholesterol levels of subjects from the three areas in the age group 15-16.9 years. However, in the age group 17-18.9 years, subjects in the Kurunegala area had a lower prevalence of risk factors ie. significantly lower BMI and serum total cholesterol and apolipoprotein B concentrations than those in other areas. Overall, smoking prevalence was 4.5%, and higher in Colombo than in Negombo and Kurunegala. Further, the mean intake of cholesterol was significantly lower and the fibre intake was higher among subjects in Kurunegala, than those in other areas. Thirty two percent of subjects had a family history of coronary artery disease, hypertension or diabetes and these subjects had significantly higher BMI values than those who did not have a family history of the above diseases, but their lipid patterns were similar. Thus high BMI was a major factor leading to hypercholesterolaemia.

Key words: Adolescence, boys, Sri Lanka, Colombo, Negombo, Kurunegala, Coronary risk factors, smoking, serum lipids, anthropomotry, BMI, dietary habits, fat intake, dietary fibre intake

Introduction

The incidence of cardiovascular disease (CVD) is increasing in many developing countries and is the leading cause of hospital deaths among adults in Sri Lanka. The number of deaths due to ischaemic heart disease has increased from 5.6 per 100,000 population in 1970 to 18.2 in 1992[1]. This alarming increase can be attributed to a number of factors, of which changes in dietary habits and life style are important.

Atherosclerosis, the pathogenic process leading to CVD, is a slowly progressive disease and commences in childhood. In the Bogalusa heart study, it was reported that high lipid levels in adolescent boys and girls correlated positively with changes in vasculature predictive of later CVD[2]. Further, it has been shown that there is a tendency to persistence in ranks (tracking) for serum total and β-lipoprotein cholesterol with age[3]. Therefore, attempts should be made to normalize lipid patterns by modifying dietary habits and lifestyles, as intervention measures adopted early in life will have the greatest effect.

Previous studies on Sri Lankan adult males in the 20 to 50 year age group showed that 21.2 % of apparently healthy subjects had total serum cholesterol levels greater than 240mg/dL (Atukorala *et al*, Unpublished observations, 1991). It is necessary to determine whether adolescent boys also have undesirable lipid patterns.

The objectives of this study were to examine the risk of cardiovascular disease due to hyperlipidaemia in apparently healthy adolescent school boys and to determine a possible relationship between their lipid patterns and dietary habits. This would enable the identification of important risk factors among adolescent schoolboys in Sri Lanka, so that an educational program could be planned to promote healthy lifestyles.

Materials and Methods

Subjects

Six hundred and thirty seven boys in the 10th to 13th year of school (Grades 9 to 12) were randomly selected from those attending four large schools in Colombo (n=416), the capital of Sri Lanka, and the two largest schools in each of two cities, namely, Negombo in the Western Province (n=120) and Kurunegala in the North Western Province (n=101). Their ages ranged from 14 to 18 years, with a mean age of 16.7±1.3 years. Subjects with a history of any major illness were excluded.

Methods

Information regarding their socioeconomic status, sports and recreational activities during the past week, both during school hours and after school, their past medical history and history of CVD, hypertension or diabetes in one or both

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parents (before 60 years of age) was noted by means of an interviewer-administered questionnaire. The subjects were classified according to the social class classification based on the occupation and income of chief occupant of the household.[4] A dietary history was also obtained on two occasions by the 24 hour dietary recall method using an interviewer-administered questionnaire. The daily intake of energy, fat (total, saturated, monounsaturated and polyunsaturated), cholesterol and fibre were calculated from food composition tables[5-7]. To ascertain their smoking habits, the subjects were given a questionnaire in which a number was the only means of identifying each subject. They were asked to complete it individually. Confidentiality of the data was ensured.

The weight, height and mid upper arm circumference of each subject was measured by the same investigator and the body mass index (BMI) was calculated using the following formula: $BMI(kg/m^2) = weight(kg)/height^2(m^2)$

Laboratory methods

A 10ml sample of blood was collected by venepuncture from each subject after a 12 hour fast. The separation of HDL and non-LDL fractions in the serum was carried out within 3 hours of collection of blood.

The HDL fraction was separated using phosphotungstic acid, Mg2+ reagent.[8] The LDL fraction was precipitated from the serum[9] using polyvinyl sulphate (Catalogue no. 726290, Boerhinger Mannheim, Germany) and the cholesterol content of the supernatant non-LDL fraction was determined. Total cholesterol, HDL cholesterol and non-LDL cholesterol concentrations were estimated by an enzymatic method using reagent kits (Catalogue no. 236991) obtained from Boerhinger Mannheim, Germany. The LDL cholesterol concentration was calculated by subtracting the non-LDL cholesterol concentration from the total cholesterol concentration. The concentration of apolipoprotein B was determined by rocket electrophoresis[10] using antisera obtained from Boerhinger Mannheim, Germany. All estimations were carried out in duplicate and a quality control serum was analysed with every batch of assays.

Statistical analysis was carried out on an IBM compatible computer using Epi Info version 5.0. The methods used were the Student's t-test, analysis of variance and simple and multiple regression analysis. When samples were not normally distributed, or where the variances were not homogeneous, the Kruskal-Wallis test was used and the H value was calculated to assess the level of significance. This study was approved by the Ethical Review Committee of the Faculty of Medicine, University of Colombo, Sri Lanka and subjects gave informed consent.

Results

The subjects were categorized according to occupation of the chief occupant of the household, and 71 percent of the subjects belonged to social classes two (ie. skilled occupations requiring secondary education) or three (ie. occupations requiring upper primary or lower secondary education). The median monthly income per family was Sri Lankan Rupees 9413 in Colombo (USDollars 188), Rupees 5000 in Negombo (US Dollars 1003 and Rupees 4000 in Kurunegala (US $80).

Anthropometric data

The weight, height and mid-arm circumference of adolescent males belonging to different age groups is given in Table 1. Subjects in the 16 year age group (16-16.9 years) had a significantly higher mean height, weight and mid-arm circumference than those in the 14 (14-14.9 years) and 15 year (15-15.9 years) age groups, whereas, there was no significant difference between the mean values of the 16, 17 (17-17.9 years) and 18 (18-18.9 years) year age groups.

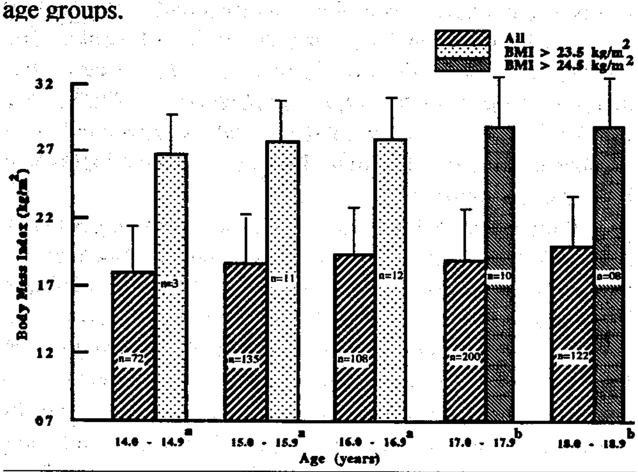
Table 1. Anthropometric measurements of adolescent males in different age groups.

Age Group	No of subjects	Height (cm)	Weight (kg)	Mid arm circumference (cm)
14.0- 14.9=14	72	160±9	46.4±10.9	22.1±3.4
15.0-15.9=15	135	164±6	49.7±10.7	22.1±3.4
16.0-16.9=16	108	167±6[a]	53.7±11.3[b]	23.6±3.3[c]
17.0-17.9=17	200	168±6	53.3±9.6	23.7±3.0
18.0-18.9=18	122	169±8	56.6±9.6	24.5±3.0
All	637	166±7	52.5±10.7	23.4±3.2

Values are means ± SD.
[a] Significantly higher than age groups 14 ($p < 0.0001$) and 15 ($p < 0.001$).
[b] Significantly higher than age groups 14 ($p < 0.001$) and 15 ($p < 0.01$).
[c] Significantly higher than age groups 14 ($p < 0.01$) and 15 ($p < 0.02$).

The mean body mass index (BMI) of subjects studied was 18.9±3.4kg/m^2. A BMI value of 23.5kg/m^2 was used as the cut-off value suggestive of obesity in the age groups 14-16 years and a value of 24.5kg/m^2 was used as the cut-off value for- the older age groups. Seven percent of 637 subjects had BMI values greater than the respective cut-off values (Figure 1). A highly significant positive correlation was noted between BMI and mid-arm circumference ($r=0.84$, $p<0.001$).

Figure 1. BMI of adolescent males belonging to different age groups.



Values are means ± SD for each age group. a- cut-off value for BMI = > 23.5 kg/m^2; b- cut-off value for BMI = >24.5 kg/m^2

To compare the anthropometric parameters among subjects in the three areas of Colombo, Negombo and Kurunegala, the subjects were categorized into two groups, 15-16.9 and 17-18.9 years. The age group 14-14.9 years was excluded as the subjects studied in this age group were only from Colombo. There was no significant difference in anthropometric parameters among subjects in the three areas in the age group 15-16.9 years (Table 2). However, in the age group 17-18.9 years, subjects in Colombo had a significantly higher mean height and BMI than those in the other two areas (Table 2).

Table 2. Anthropometric measurements of adolescent males attending schools in the three areas.

	BMI (kg/m^2) All subjects	> Cut off value	Height (cm)	Mid-arm circumference (cm)
Age 15.0 - 16.9 years[a]				
Colombo (n=167)	18.7±3.5	26.6±1.9 (19)	165±7	23.1±3.4
Negombo (n=27)	18.9±4.0	30.6±5.9 (02)	169±5	23.4±3.6
Kurunegala (n=49)	18.5±3.0	29.6±6.5 (02)	164±7	22.8± 2.7
Age 17.0 - 18.9 years[b]				
Colombo (n=177)	19.9±3.7[c]	29.0±3.4 (16)	169±8[d]	24.6± 3.2[e]
Negombo (n=93)	18.5±2.7	27.3±3.4 (02)	169±5	23.1 ± 2.4
Kurunegala (n=52)	18.1±2.1	-	167±5	23.3±2.5

Values are means ±SD
[a] Cut off value for Body Mass Index (BMI) 23.5 kg/m^2
[b] Cut off value for Body Mass Index (BMI) 24.5 kg/m^2
[c] Significantly higher than subjects in the same age group in Kurunegala ($p < 0.001$) and Negombo ($p < 0.005$)
[d] Significantly higher than subjects in Kurunegala ($p < 0.01$)
[e] Significantly higher than subjects in the same age group in Kurunegala ($p < 0.02$) and Negombo ($p < 0.001$).

Table 3. Total cholesterol, LDL cholesterol and apolipoprotein B concentration in the serum of adolescent males belonging to different age groups.

Age group (years)	Total cholesterol (mg/dL)[a]	LDL cholesterol (mg/dL)[a]	Apolipoprotein B (mg/dL)
14.0-14.9=14	167±24(71)[b]	102±22(71)[c]	75.5±11.7(63)[d]
15.0-15.9=15	156±25(133)	89±24(130)	71.8±14.9(119)
16.0-16.9=16	152±28(106)	85±30(104)	71.7±17.6(95)
17.0-17.9=17	156±28(196)	90±27(193)	71.1±17.8(188)
18.0-18.9=18	168±27(119)[b]	98±28(114)[c]	78.4±14.6(109)[e]
All	159±27(625)	92±27(612)	73.2±16.3 (574)

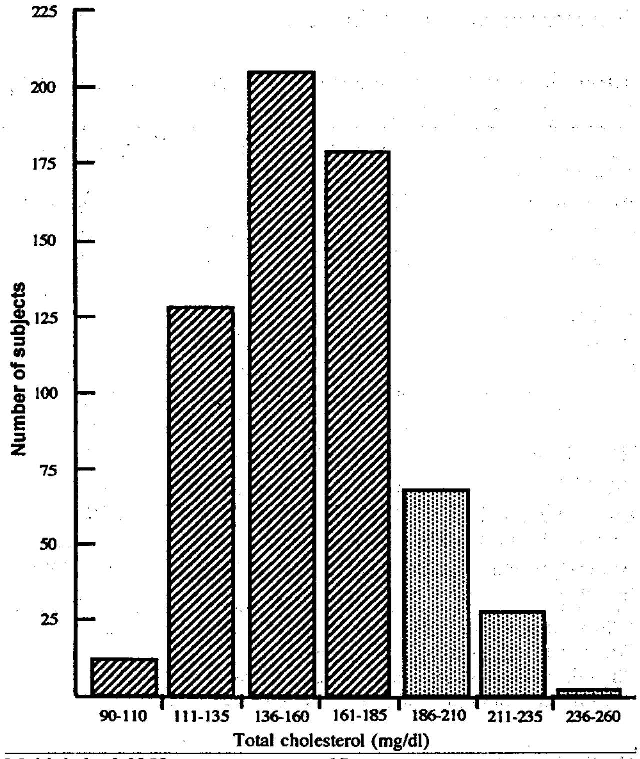
Values are mean ±SD for each age group. Number of subjects is indicated in parentheses.
[a] Multiply by 0.0258 to convert to mmol/L
[b] Significantly higher than age groups 15, 16 and 17 ($p < 0.01$).
[c] Significantly higher than age groups 15, 16 and 17 ($p < 0.005$).
[d] Significantly higher than other age groups ([d] $p < 0.05$, [e] $p < 0.001$).

Laboratory data

The total cholesterol concentration in the serum was estimated in 625 subjects and the mean value was 159.0 (SD=27.2)mg/dL (4.11±0.70 mmol/l). The distribution of total cholesterol in the serum is given in Figure 2. Values greater than 185mg/dL (>4.78 mmol/l) were noted in 103 subjects (16.5%) and 91 of these subjects had values greater than 200mg/dL (>5.17mmol/l). The mean serum total cholesterol, LDL cholesterol and apolipoprotein B concentrations were significantly higher in age groups "14" and 18 years than in other age groups (Table 3) The serum total cholesterol concentration showed a significant increase with age ($r=0.18$, $F=17.7$, $p<0.001$), when the 14 year age group was excluded. High LDL cholesterol concentrations (>110 mg/dL:>2.84 mmol/l) were noted in 134 subjects (21.9%) and the percentage of subjects with elevated LDL cholesterol was highest (29.8%) in the 18 year age group. A significant positive correlation was noted between LDL cholesterol and apolipoprotein B concentrations ($r=0.86$, $F=433$, $p<0.001$). Twenty three percent (n=132) of subjects had apolipoprotein B concentrations greater than 85 mg/dL.

The mean HDL cholesterol concentration was 43.1 (SD=11.0) mg/dL (1.11 mmol/L) and 164 subjects (27.3 %) had values less than 35 mg/dL: 0.91 mmol/L (Table 4). The mean ratio of LDL cholesterol to HDL cholesterol was significantly higher in age groups 14 and 18 years than in other age groups (Table 4).

Figure 2. Serum total cholesterol levels of adolescent males.



Multiply by 0.0258 to convert to mmol/L.

Table 4. HDL cholesterol, and the ratio of LDL cholesterol to HDL cholesterol in the serum of adolescent males belonging to different age groups.

Age Group (years)	HDL chol (mg/dL) All subjects	< 35 mg/dL	LDL chol / HDL chol
14.0-14.9=14	39.5±9.3 (69)	30.6±3.5 (24)	2.71±0.93 (69)[c]
15.0-15.9=15	41.4±10.4 (123)	30.4±3.3 (39)	2.27±0.87 (123)
16.0-16.9=16	41.8±11.7 (101)	29.5±4.1 (32)	2.18±1.02 (101)
17.0-17.9=17	46.2±10.9 (194)[a]	31.1±2.8 (37)	2.11±0.99 (194)
18.0-18.9=18	42.9±11.1 (114)	30.3±3.2 (32)	2.43±0.94 (114)[b]
All subjects	43.1±11.0 (601)	30.4±3.4 (164)	2.28±0.97 (601)

Values are means ±SD. Number of subjects is indicated in parentheses. Multiply by 0.0258 to convert to mmol/l (35mg/dL = 0.91 mmol/l)
[a] Significantly higher than other age groups ($p < 0.02$). [b] Significantly higher than other age groups ([b]$p < 0.05$, [c]$p< 0.005$).

The lipid patterns were compared in subjects belonging to the same age group in Colombo, Negombo and Kurunegala. There was no significant difference in the mean serum total cholesterol or HDL cholesterol concentration of subjects from Colombo, Negombo and Kurunegala in the age group 15-16.9 years (Table 5). In contrast, in the age group 17-18.9 years, the mean serum total cholesterol concentration of subjects in the Kurunegala area was significantly lower than in Colombo and Negombo (Table 6). Further, 36 subjects in Colombo (20.1%) and 15 subjects in Negombo (16.8 %) had high serum total cholesterol levels (ie. >185 mg/dL: 4.78 mmol/L), while only four subjects in Kurunegala (8.7 %) had high total cholesterol levels. The HDL cholesterol concentration was significantly lower ($p<0.001$) among subjects in Colombo than those in other areas (Table 6).

Table 5. Serum lipid patterns of subjects in the age group 15 - 16.9 years from the three areas.

	Colombo	Negombo	Kurunegala
Total cholesterol			
All subjects (mg/dL)a	152±27 (164)	159±24 (27)	158±28 (48)
> 185 mg/dL	201±13 (20)	195±12 (05)	205±13 (07)
LDL cholesterol			
All subjects (mg/dL)[a]	82.2±25.9 (161)[b]	94.0±23.6 (27)	97.8±28.4 (48)
>110 mg/dL	128.7±15.6 (20)	126.4±14.3 (07)	132.6±14.1 (15)
HDL cholesterol (mg/dL)[a]	42.5±10.6 (156)	42.5±10.5 (26)	37.7±11.9 (48)
LDL cholesterol / HDL cholesterol	2.02±0.73 (156)[c]	2.37±0.94 (26)	2.91±1.42 (48)
Apolipoprotein B (mg/dL)	68.1±13.4 (143)[c]	75.5±18.9 (25)	80.4±18.4 (48)

Values are means ±SD. Number of subjects is given in parentheses.
[a]Multiply by 0.0258 to convert to mmol/l.
[b]Significantly lower than subjects in other areas ($p < 0.05$).
[c]Significantly lower than subjects in Kurunegala ($p < 0.01$).

Dietary data

The mean energy and nutrient intakes of subjects belonging to different age groups is given in Table 7. The mean percentage of energy derived from fat was 18.0 (SD=7.9), with a range of 17.0 to 19.9. There was no significant difference in the intake of total fat or the ratio of saturated fat to monounsaturated and polyunsaturated fat in the different age groups. The intake of fibre was higher in age groups 16 years and above than in lower age groups, but the difference was statistically significant ($p<0.02$) only when the 18 year age group was compared with the age groups 14 and 15 years (Table 7).

The energy and nutrient intakes of subjects in the age group 15-16.9 years from the three areas is given in Table 8. The mean percentage of energy derived from fat was similar in the three areas. In age groups 15-16.9 years and 17-18.9 years, the daily cholesterol intake and the intake of cholesterol per 1000kcal was significantly lower among subjects in Kurunegala than in other areas, whereas, the fibre intake was significantly higher when compared with those in Colombo (Table 8).

Table 6. Serum lipid patterns of subjects in the age group 17 - 18.9 years from the three areas.

	Colombo	Negombo	Kurunegala
Total cholesterol			
All subjects (mg/dL)	165±27 (177)	161±25 (91)	146±30 (47)[b]
>185mg/dL	204±18 (36)	200±14 (15)	217±31 (04)
LDL cholesterol			
All subjects (mg/dL)[a]	96.3±27.7 (173)	92.5±24.9 (90)	82.1±32.6 (46)[d]
>110mg/dL	130.6±17.2 (49)	126.1±14.5 (23)	148.5±29.7 (06)
HDL cholesterol (mg/dL)[a]	41.9±10.3 (173)[c]	48.5±10.1 (91)	49.8±12.2 (45)
LDL cholesterol / HDL cholesterol	2.43±0.94 (173)	2.03±0.77 (90)	1.89±1.33 (45)[b]
Apolipoprotein B (mg/dL)	75.1±14.7 (164)	76.5±19.4 (89)	64.3±17.4 (46)

Values are means±SD. Number of subjects is given in parentheses.
[a] Multiply by 0.0258 to convert to mmol/L.
[b] Significantly lower than subjects in other areas ([b] $p < 0.005$, [d] $p < 0.001$).
[c] Significantly lower than subjects in other areas ($p < 0.001$).

Table 8. Energy and nutrient intakes of adolescent males belonging to the age group 15-16.9 years in the three areas.

	Colombo (n=165)	Negombo (n=27)	Kurunegala (n=49)
Energy (kcal/d)	1946±607	2408±644[a]	1934±749
Protein (g/d)	63.8±21.9	76.9±22.3	68.0±30.4
Total fat (g/d)	42.9±29.2	42.3±18.6	35.9±25.1
Energy (%)	18.9±8.8	15.7±5.0	16.0±8.2
Saturated fat / MUF +PUF	1.69±0.79	1.15±0.41	1.81±1.27
Cholesterol (mg/d)	145±124	148±90	87±80[b]
Cholesterol (mg/1000 kcal)[a]	73.7±54.4	64.9±46.1	51.0±43.9[c]
Fibre(g/d)	7.15±3.29	9.79±4.16[b]	8.89±4.34[b]

Values are means ± SD.
MUF = Monounsaturated fat, PUF = Polyunsaturated fat
Energy from fat (kcal/d) x 100/Total energy (kcal/d),
a = Cholesterol intake (mg/d) X 1000 / Energy intake (kcal/d)
[a] Significantly higher than subjects in other areas ($p < 0.01$)
[b] Significantly different from subjects in Colombo ([b] $p < 0.02$, [c] $p < 0.005$)

Table 7. Energy and nutrient intakes of subjects belonging to different age groups.

Age Group	N	Energy (kcal/d)	Fat energy (%)	Saturated fat / MUF + PUF	Cholesterol (mg/d)	Fibre (g/d)
14.0-14.9 = 14	71	1970±636	19.9±7.1	1.86±0.86	136± 95	7.30±2.68
15.0-15.9 = 15	133	1919±576	18.6±8.6	1.65±0.92	137±113	7.70±3.84
16.0-16.9 = 16	108	2167±672[a]	17.2±8.2	1.66±0.87	135±122	8.27±3.48
17.0-17.9 = 17	195	2148±624	17.0±7.4	1.75±0.91	142±126	8.49±4.41
18.0-18.9 = 18	122	2230±660	18.1±8.3	1.65±0.89	159±138	8.64±3.71[b]
All Subjects	629	2099±641	18.0±7.9	1.71±0.89	142±122	8.17±3.85

Values are means ± SD; MUF = Monounsaturated fat; PUF = Polyunsaturated fat; Fat energy % = Energy derived from fat (kcal/d) x 100/Total energy(kcal/d); [a] Significantly higher than age groups 14 and 15 years ([a] $p<0.005$); [b] Significantly higher than age groups 14 and 15 years ($p<0.02$)

Family history

There were 202 subjects with a family history of coronary artery disease (CAD), hypertension, diabetes mellitus, or more than one of the above disease states. Of the 48 subjects with a family history of CAD, 14.6% had BMI values above the desirable range, while 10.4 % and 22.9 % had high concentrations of serum total cholesterol (>185 mg/dL:4.78 mmol/L) and apolipoprotein B (>85 mg/dL), respectively. Among the 98 subjects with a family history of hypertension, 7.1 % had high BMI, 12.2% had high serum total cholesterol and 25.5% had high apolipoprotein B levels. Among subjects with a family history of diabetes (n=110), the corresponding percentages were 16 % (high BMI), 21% (high serum total cholesterol) and 20.9%. (high apolipoprotein B) respectively. When the lipid profiles of subjects with a family history of one or more of the above diseases were compared with those that did not have a family history, no significant difference was noted in the serum total, HDL and LDL cholesterol concentration in the two groups. However, the mean BMI was significantly higher ($p<0.01$) among subjects with affected parents (19.4±3.5 kg/m^2) than those with no family history (mean BMI = 18.6±3.3 kg/m^2).

Smoking habits

Smoking was not a major problem among the subjects studied. Thirty-three subjects did not want to divulge smoking habits. Twenty-seven subjects (4.5%) were regular smokers, of which 22 subjects were from schools in Colombo, while only 5 subjects were from schools in Negombo or Kurunegala. There were 45 occasional smokers. There was no significant difference in the lipid profiles of regular and occasional smokers (considered together) when compared to that of non-smokers.

Relationship between variables

A significant positive association was noted between serum total cholesterol concentration and BMI ($r=0.25$, $F=41.7$, $p<0.001$) and between LDL cholesterol and BMI ($r=0.24$, $F=38.4$, $p<0.001$), while a significant negative association was noted between HDL cholesterol concentration and BMI ($r=-0.12$, $F=8.36$, $p<0.005$). A significant positive association was also noted between serum total cholesterol and mid-arm circumference ($r=0.24$, $F=37.8$, $p<0.001$).

There was a significant positive association between body weight and energy intake ($r=0.35$, $F=85.3$, $p<0.001$) and also between height and energy intake ($r=0.13$, $F=10.5$, $p<0.005$). However, there was no significant association between body mass index and the dietary energy intake, or fat intake. There was no significant association between the serum total cholesterol concentration and the intake of saturated, monounsaturated, polyunsaturated or total fat, or the ratio of saturated fat to mono- and poly-unsaturated fats. The serum total cholesterol concentration was positively related to the intake of cholesterol when expressed as mg/1000 kcal ($r=0.11$, $F=8.14$, $p<0.005$). A weak negative association was noted between serum total cholesterol concentration and energy intake from polyunsaturated fat per 1000 kcal, but it did not reach statistical significance when no adjustment was made for confounding variables.

The influence of body mass index, cholesterol intake (mg per 1000kcal) and energy intake from polyunsaturated fat (per 1000kcal) considered together on serum total cholesterol concentration was assessed by multiple regression analysis and a significant association ($F=18.7$, $p<0.001$) was noted. A significant positive partial correlation was noted between serum total cholesterol and BMI ($F=41.8$, $p<0.001$) and cholesterol intake per 1000 kcal ($F=9.23$, $p<0.005$), while a significant negative correlation was noted with energy intake from polyunsaturated fat per 1000 kcal (Partial $F=4.61$, $p<0.05$).

The regression equation is given below:

Serum total cholesterol =

$$119.7 + 2.011 \times BMI + 0.059 \times C - 0.377 \times PUF$$

(C = cholesterol intake per 1000 kcal; PUF = energy intake from polyunsaturated fat per 1000 kcal).

Discussion

There are very little data regarding lipid profiles of children, especially in developing countries. Our study was an attempt to determine whether apparently healthy adolescent school boys in Sri Lanka have undesirable anthropometric indices, lipid profiles or family histories which may increase their predisposition to CVD in adult life. The majority of the subjects included in the study in all areas belonged to social classes two or three. The monthly income per family was higher among subjects in Colombo. However, there was wide variation within the group.

A comparison of anthropometric indices in different age groups indicates that slowing of growth rates occurs after 16 years of age. There is no acceptable cut-off value suggestive of obesity in adolescent males. It may vary with age and also be affected by racial differences. The cut-off value for each age group was obtained by calculating the body mass index using the median height for each age group and weights corresponding to the 90th percentile in the NCHS standards.[11] A BMI value greater than 23.5 kg/m^2 was used as the cut-off value in age groups 14 to 16 years, while 24.5 kg/m^2 was used as the cut-off value for age groups 17 and 18 years. Seven percent of the subjects studied had BMI values above the reference range.

The mean total cholesterol concentration of subjects in our study was within the normal range. This value is similar to the mean value of 4.10 mmol/L (158.5 mg/dL) reported for 270 Australian boys 15 years of age[12], while a higher mean value was noted in 4829 children 6-18 years of age in Muscatine, Iowa, USA[13] and in 132 children in north east England.[14] In the Bogalusa study, higher serum total cholesterol levels were noted among 67 black boys 14 years of age, than in 116 white boys in the same age group[15]. Serum total cholesterol levels above the 90th percentile ie. 185 mg/dL, the value above which dietary intervention is recommended[16], was used as the cut-off value in our study and 16.5% had these high values. In contrast, in a study of 239 school children aged 5-19 years from low-middle income families in Karachchi, Pakistan, a serum cholesterol concentration of 4.4 mmol/L (170 mg/dL) or more was used as the cut-off value, and 22% of the boys had these high values[17] as compared with 26.4 % in our study.

The mean serum total cholesterol concentration was higher in the 14 year age group than in the 15 year age group. It is possible that the higher mean values noted in the 14 year age group were due to the fact that subjects in this age group were mainly from Colombo. However, the difference was significant even when only subjects from Colombo belonging to different age groups were considered. The higher mean values noted in the 14 year age group than in the 15 and 16 year age groups could be due to the profound physiological changes that occur during this period and the increased need for cholesterol for sex hormone synthesis during puberty. A significant age dependent increase in serum total cholesterol was noted from 15 to 18 years of age. The serum total cholesterol concentrations in the age group 18 years probably reflect levels that may be found in adults.

Elevated serum LDL cholesterol levels (>110 mg/dL: 2.84mmol/L) were noted in 134 subjects (21.9%) and the percentage of subjects with high LDL cholesterol levels was highest (29.8 %) in the age group 18 years. There are no recommended cut-off values to identify high apolipoprotein B levels in adolescents. A cut-off value of 85mg/dL was chosen for our study population. The data on apolipoprotein B levels of children is limited and other workers have not used a cut-off of 85mg/dL. Twenty three percent (n=132) of the subjects had these high values. It is important to note that 164 subjects (27.3 %) had low HDL cholesterol levels, which could either be due to reduced need for cholesterol scavenging when the diet contained only small amounts of animal foods, or to reduced physical activity. It was noted that 437 subjects (68.6 %) did not engage in any sports or recreational activities. Furthermore, only a maximum of 45 minutes per week has been assigned for physical training or sports activities during school hours.

Our studies indicate that high BMI was a major factor associated with hypercholesterolaemia and that cholesterol intake per 1000 kcal and polyunsaturated fat intake were also associated contributory factors, though less important. Intake of saturated fats did not have a significant effect, probably because the proportion of energy derived from fat was less than 20%.

The anthropometric parameters of subjects from the three areas in the age group 15-16.9 years were similar. In contrast, in the age group 17-18.9 years, subjects from schools in the Colombo area had higher mean values for all anthropometric parameters than those in other areas. It is also noteworthy that in both age groups, the number of subjects with BMI above the respective cut-off values was also highest in Colombo and lowest in Kurunegala. This difference could be attributed at least in part to unfavorable life styles among subjects in Colombo.

The mean serum total cholesterol levels of subjects from the three areas in the age group 15-16.9 years were similar. However, the LDL cholesterol levels of subjects in Kurunegala were higher. The reason for the occurrence of high LDL cholesterol levels among these subjects is not clear, as there was no difference in food habits when compared to the older age group. In contrast, in the age group 17-18.9 years, subjects in Kurunegala had the most favorable lipid profiles, whereas, a higher percentage of subjects in Colombo had undesirable values ie. high serum total and LDL cholesterol and apolipoprotein B and low HDL cholesterol concentrations.

A comparison of the food intakes of subjects in the three areas, showed that the percentage of energy derived from fat was similar in the three areas in both age groups. However, the intake of cholesterol and cholesterol per 1000 kcal was lowest among subjects in Kurunegala and highest in Colombo, indicating a higher consumption of animal foods. It is important to note that the higher intake of cholesterol among subjects in Colombo was due at least partly to the increased consumption of snack foods and meats, specially processed meats. Furthermore, the fibre intakes were lower than in other areas. In Negombo, the cholesterol intakes were similar, but their fibre intakes were higher. The food habits of subjects in Kurunegala were similar to traditional Sri Lankan diets, with smaller amounts of animal products, especially processed foods and higher fibre intakes. Although, the proportion of dietary fat derived from coconut was higher among subjects in Kurunegala area than in other areas, it did not have a cholesterol elevating effect, probably because the diet also contained a higher fibre (and related plant component) content.

Nearly 32% of the subjects studied had a family history of diabetes mellitus, hypertension or coronary artery disease (CND). However, CND was less common among parents of subjects studied, than diabetes or hypertension. Only 10% of subjects with a family history of CAD had elevated serum total cholesterol levels, while 22.9% had high apolipoprotein B levels. Thus familial hypercholesterol-aemia was less common in our study population. However, an important finding in our study was the observation of significantly higher mean BMI among subjects with a family history of CHD, hypertension or diabetes, when compared with those that did not have a family history of the above diseases. This difference could be due either to improper dietary practices, or to a familial tendency to have excessive body weight.

In summary, 16.5% of the subjects studied had high serum total cholesterol levels and the percentage of subjects with high LDL cholesterol and apolipoprotein B concentrations were 21.9% and 23.0% respectively. These undesirable lipid patterns could be attributed at least partly to excessive body weight, to high intake of cholesterol rich animal foods and to low intakes of polyunsaturated fat per unit energy. The percentage of subjects with high BMI and undesirable lipid patterns was markedly higher in Colombo than in other areas. Although familial hypercholesterol-aemia was less common in our study population, there was a tendency to have high body mass indices among children of affected parents. It is proposed that a cereal based diet with a high fruit and vegetable content should be promoted among school children and the increasing trend towards consumption of processed foods, especially processed meats should be discouraged. It is also necessary to promote regular recreational physical activities to achieve energy balance or acceptable levels of food intake.

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Lipid profiles and dietary habits of adolescent school boys in Sri Lanka

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摘要

作者在青少年學校選了 637 名 10 至 13 年級（平均年齡 16.7±1.3 歲）的男孩，分別測定了他們的膳食習慣，人體測量數據和血脂水平，祈求識別這些青少年在晚年心血管病危險因素的患病率。對象來自首都哥倫布 (Colombo, n = 416) 和其它兩個城市。7% 的對象 BMI 值大於參考範圍，絕大部份對象平均血清總膽固醇濃度在正常範圍内（158.9±27.2 毫克/100 毫升血清；4.11±0.7 毫克分子量/升），僅 16.5% > 185 毫克/100 毫升血清，高 LDL 膽固醇（> 110 毫克/100 毫升血清）和高脫輔基脂蛋白 B（apolipoprotein B > 85 毫克/100 毫升血清）的對象分别佔 21.9% 和 23.0%。而低 HDL 膽固醇者佔 27.3%。BMI 與血清總膽固醇濃度有明顯的正相關 (p < 0.001)。在 15-16.9 歲年齡組，三個城市的平均 BMI 和總膽固醇沒有明顯差異。但是，在 17-18.9 歲年齡組， Kurunegala 地區危險因素的患病率較低。其 BMI 、血清總膽固醇和脫輔基脂蛋白 B 濃度明顯低於其它地區。此外，Kurunegala 地區的男孩平均膽固醇進食較其它地區爲低，但纖維素進食則較高。32% 對象有冠狀動脈疾病、高血壓或糖尿病家族史，他們的 BMI 明顯高於沒有上述疾病家族史的男孩。作者認爲高 BMI 是引起高膽固醇血症的重要因素。

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