ORIGINAL ARTICLE

Serum Lipid & Lipoprotein Profiles of Obese Chinese Children

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Summary

The serum lipid and lipoprotein levels of 59 obese Chinese children with a mean age of 13.0 years and mean relative weight of 164.2% were analysed. Between 40% to 54% of these children had elevated lipid and lipoprotein levels and about 78% had reduced high density lipoprotein (HDL) level when compared to healthy American and Japanese children. The obese children also had higher mean levels of total cholesterol (TC) and lower HDL compared to male adults in the local population. Those with elevated TC had higher mean relative weight (170% vs 159%, $p < 0.05$). In view of the close association between hyperlipidaemia and atherosclerosis, obese children should be carefully screened and managed to prevent long term morbidity and mortality of coronary artery disease.

Key Words: Childhood obesity, Hyperlipidaemia, Atherosclerosis

Introduction

Obesity is commonly associated with hyperlipidaemia in adults[1,2] and this association may partially account for the relationship between obesity and coronary heart disease[1]. In a study of subjects between 16 and 81 years of age in Australia[2], plasma cholesterol and triglyceride levels were found to be positively correlated with body mass index, which was used as a measure of obesity. Other workers reported significant correlation between body habitus and plasma lipid and lipoprotein levels in children and adolescents[3,4].

The interest in hyperlipidaemia and childhood obesity arises because obesity and hyperlipidaemia are both risk factors for coronary heart disease and lipids have a contributory role in atherogenesis[5]. Autopsy studies of adolescents and young individuals revealed sobering evidence of coronary atherosclerotic changes[6,7]. It is believed that pathologic precursors of coronary artery disease may possibly have their origins in childhood[8-10].

Although there is abundant information relating obesity to hyperlipidaemia and coronary artery disease in adults, studies linking these to childhood obesity is less confirmative. In this study we determined the levels of serum lipids and lipoproteins of obese children and compared the results with those of male adults in our population as well as with age and sex-specific values of healthy American and Japanese children. Lipid and lipoprotein values of obese children in this study were also related to their anthropometric indices of obesity like body weight, relative weight and body mass index.

Materials & Methods

Fifty-nine obese children (36 males, 23 females; 44 Chinese and 15 Malays) from the Obesity Clinic of the School Health Services, Ministry of Health, Singapore, were assessed. Informed consent for the study was obtained from parents of the children. Body weights and heights of the children were

measured using standard epidemiological techniques. Body weight was determined to the nearest 0.1 kg using a beam balance scale. Standing height was measured to the nearest 0.1 cm using a vertical scale against the wall. Relative weight (RW) was derived from the ratio of actual weight to the age and sex-specific 50th percentile weight-for-height. They were defined obese by a RW of above 120%. Body mass index (BMI) was calculated from the formula: weight (kg) divided by height (m) to the power of two (weight/height^2).

The obese children were otherwise healthy with no history of recent illness. Their ages ranged from 7.4 years to 19.2 years (mean age: 13.0 years), with 7 children between 5 to 9 years old, 37 children between 10 to 14 years old and 15 children between 15 to 20 years old. This grouping by age was later used in the comparison of lipid and lipoprotein levels between children in this study and American children. The RW of our children ranged from 124% to 247% (mean RW: 164.2%). As there was no significant difference between the Chinese and Malay children as well as between the male and female children, they were considered together for analyses of results.

The children were carefully instructed to fast for a minimum of 12 hours overnight. For ethical reasons, venepuncture was limited to a maximum of two attempts per child. Venous blood samples were collected into plain sterile tubes. Each blood sample was allowed to clot under room temperature and then centrifuged at 3000 rpm for 15 minutes. The serum obtained was divided into 3 aliquots as follows:

a. 0.5 ml for determination of triglyceride (TG) and total cholesterol (TC).

b. 1.0 ml for determination of high density lipoprotein-cholesterol (HDL-C).

c. 2.0 ml for determination of low density lipoprotein-cholesterol (LDL-C) and very low density lipoprotein-cholesterol (VLDL-C).

TG and TC were determined by enzymatic methods described by Bucolo and David[11] and a modified method of Richmond[12], respectively.

HDL-C was quantified after the chilled serum was precipitated with 5% heparin and 10% manganese chloride. The mixture was centrifuged at 12,000 rpm for 2 minutes and the supernatant was removed for determination of HDL-C using the enzymatic method described by Burstein *et al*[13].

The aliquot of serum for determination of LDL-C and VLDL-C was first mixed with 0.15M sodium chloride solution containing 0.001M tetra-sodium EDTA and then centrifuged at 40,000 rpm for 18 hours in a Beckman L5-50 ultracentrifuge. The centrifuged sample was then removed and fractionated with a Beckman tube slicer. The top and lower fractions were reconstituted with 0.15M sodium chloride solution and used for enzymatic analyses of VLDL-C and [HDL-C + LDL-C][14]. LDL-C was derived by substracting HDL-C from [HDL-C + LDL-C].

Cultural inhibitions towards venepuncture made it difficult to obtain normal non-obese age and sex-matched controls for the obese children at the time of the study. As an alternative, we compared the results with age and sex-matched values of healthy American children[15,16] and those of 15-year-old Japanese children[17] as well as normal adults in our population[18]. Although there were methodological and demographic differences in such comparisons, it will give us an estimated extent of the deviation of lipid and lipoprotein levels of obese children from population values.

The differences between means were compared using the z statistic method. For sample numbers less than 30, Student's t test was used to assess the significance of difference between two means. Pearson's correlation was used to correlate lipid and lipoprotein levels with anthropometric measurements.

Results

Table I shows the mean (SD) values of lipids and lipoproteins of obese children in this study. No significant differences exist between the males and females.

Although the more obese children (RW ≥ 160%) had higher mean triglyceride (131 mg/dL vs 111 mg/dL),

Table I
Serum lipid and lipoprotein values (mean ± SD) of obese children

Lipids & Lipoproteins	Male (n=36)	Female (n=23)	Total (n=59)
Triglyceride (mg/dl)	129.8 ± 69.5	106.0 ± 31.7	120.5 ± 58.6
Total cholesterol (mg/dl)	194.8 ± 43.8	185.4 ± 26.6	191.2 ± 38.0
HDL-cholesterol (mg/dl)	28.2 ± 10.4	27.8 ± 10.8	28.0 ± 10.5
LDL-cholesterol (mg/dl)	138.8 ± 39.1	134.4 ± 29.4	137.1 ± 35.4
VLDL-cholesterol (mg/dl)	27.9 ± 14.1	23.2 ± 6.7	26.1 ± 12.0

There is no significant difference between male and female children.
HDL = High density lipoprotein
LDL = Low density lipoprotein
VLDL = Very low density lipoprotein

total cholesterol (199 mg/dL vs 184 mg/dL), LDL-cholesterol (145 mg/dL vs 130 mg/dL) and VLDL-cholesterol (28 mg/dL vs 24 mg/dL) compared to the less obese children (RW < 160%), and lower mean HDL-cholesterol (26mg/dL vs 30 mg/dL), these differences were not statistically significant.

At least 41% to 46% of obese children of various age groups in this study had TG and TC above the age and sex-matched 95th percentile values of healthy American children[15] (Table II). A similar trend exists for lipoproteins LDL-C and VLDL-C while 78% of obese children had HDL-C values below 5th percentile values of American children[16]. Comparison of lipid values with those of 15-year-old Japanese children[17] reveals that about 47% and 42% of our obese children had elevated TG and TC, respectively, above 2 standards deviations from the mean TG and TC levels of Japanese children.

Mean TG and TC of obese children were compared with age and sex-specific means of American children[16]. The obese children in this study had significantly higher mean TC and TG ($p < 0.0001$ to < 0.01) (Table III). Comparing mean TC and HDL-C levels of obese children with those of normal Chinese male adults in this population[18] reveals that the obese children had significantly lower mean HDL-C value ($p < 0.001$). While mean TC of the obese children was also higher than that of the adults, the difference was not statistically significant.

Lipid and lipoprotein levels were correlated with anthropometric parameters (Table IV). RW was much better correlated with TC ($r=0.35$, $p < 0.01$) and LDL-C ($r=0.31$, $p < 0.02$). Body weight and BMI, however, showed weak and non-significant correlation with lipids and lipoproteins in these obese children.

Anthropometric parameters of obese children whose serum lipid and lipoprotein levels were either elevated or not elevated (in comparison with those of age and sex-specific values of American children) were compared. It is observed that obese children with either elevated TG or lipoproteins were not significantly different from those without elevated TG or lipoproteins in terms of weight, RW and BMI. The mean RW of those with elevated TC, however, was significantly higher than those with normal TC (170.4% ± 25.5% vs 159.0% ± 17.9%, $p < 0.05$, $n=32$).

Discussion

The exact mechanisms that link obesity and hyperlipidaemia are unknown. The total stores of cholesterol were increased in direct proportion to degree of obesity[19], and a high correlation between size

Table II
Proportion of obese children with levels of serum lipids and lipoproteins above the 95th percentiles (HDL-cholesterol below 5th percentile) of healthy American children in the same age group*, and with levels of serum lipids more than 2 standard deviations of the means of 15-year-old Japanese children+

Serum lipids & lipoproteins*		Proportions of obese children (%)
Triglycerides		
5 - 9 year old	(n=7)	28.6
10 - 14 year old	(n=37)	40.5
15 - 19 year old	(n=15)	46.7
Total	(n=59)	40.7
Total cholesterol		
5 - 9 year old	(n=7)	71.4
10 - 14 year old	(n=37)	40.5
15 - 19 year old	(n=15)	46.7
Total	(n=59)	45.8
HDL-cholesterol		
5 - 9 year old	(n=7)	71.4
10 - 14 year old	(n=37)	73.0
15 - 19 year old	(n=15)	93.3
Total	(n=59)	78.0
LDL-cholesterol		
5 - 9 year old	(n=7)	85.7
10 - 14 year old	(n=37)	48.6
15 - 19 year old	(n=15)	53.3
Total	(n=59)	54.2
VLDL-cholesterol		
5 - 9 year old	(n=7)	28.6
10 - 14 year old	(n=37)	62.2
15 - 19 year old	(n=15)	46.7
Total	(n=59)	54.2
Serum Lipids+		
Triglycerides		47.4
Total cholesterol		42.4

* *The Lipid Research Clinics Program Epidemiology Committee 1975[15]; Tamir* et al *1981[16]*
\+ *Ueshima* et al *1982[17]*
HDL = High density lipoprotein
LDL = Low density lipoprotein
VLDL = Very low density lipoprotein

of adipocytes and cholesterol content of the body had been documented[20]. It was postulated that insulin may possibly have a role to play in the development of hypertriglyceridaemia[21].

In this study, levels of lipid and lipoprotein were compared with those of healthy American and Japanese children, as well as with those of male adults in Singapore. Although the comparison is not ideal, we have attempted to match the ages of children and methods of analyses as far as possible. Contrary to the findings of Court *et al*[3] where there were no differences between mean values of triglyceride and total cholesterol of obese and non-obese Australian children, obese children in our study had significantly higher mean levels of triglyceride and total cholesterol compared to that of healthy children in American and Japanese populations[16,17]. About 50% of the obese children had levels of triglyceride, total cholesterol, LDL-C and VLDL-C above the age and sex-specific 95th percentile values of American children or more than 2 standard deviations of the means for Japanese children. In about 78% of obese children HDL-C was lower than the 5th percentile values of American children. The obese children also had higher mean level of total cholesterol as well as lower mean HDL-C level when compared with adult males in our population.

The degree of obesity probably has some association with the level of lipid or lipoprotein. Relative weight was found to have a significant positive correlation with total cholesterol (r=0.35) and LDL-cholesterol (r=0.31) in our study. Children who are more obese had higher mean lipid and lipoprotein levels, and lower mean HDL-C level. Furthermore, children with elevated total cholesterol had higher mean relative weight compared to those who had normal total cholesterol levels. The relationship between body mass index (in this case W/H^3) and plasma total cholesterol was investigated in a sample of school children[22]. Mean cholesterol level was found to increase exponentially above the 50th percentile of body mass index and was highest among children with the index above the 95th percentile. In the study of Sveger *et al*[23], there was a significant positive correlation between body mass index and total cholesterol (r=0.24) as well as apolipoprotein B (r=0.37). In adults, total cholesterol also increased with body mass index[24] while HDL-cholesterol decreased. In young

Table III
Comparison of age specific mean (SD) serum lipid and lipoprotein levels of obese children with those of healthy American children*, and comparison of mean (SD) total cholesterol and HDL-cholesterol levels of obese children with those of male adults in Singapore+

	Obese children Male	American children	Significance of difference
Triglycerides			
5 - 9 year old	94.7 ± 30.3	55.4 ± 22.7	$p < 0.001$
10 - 14 year old	133.0 ± 77.3	65.6 ± 30.6	$p < 0.0001$
15 - 19 year old	149.1 ± 61.5	78.0 ± 38.1	$p < 0.0001$
Total cholesterol			
5 - 9 year old	220.7 ± 17.5	159.9 ± 25.3	$p < 0.0001$
10 - 14 year old	192.0 ± 49.3	157.6 ± 25.6	$p < 0.0001$
15 - 19 year old	182.4 ± 33.4	149.9 ± 26.5	$p < 0.01$
	Obese children Female	**American children**	**Significance of difference**
Triglycerides			
10 - 14 year old	101.6 ± 27.1	75.4 ± 30.9	$p < 0.01$
15 - 19 year old	111.6 ± 37.7	72.4 ± 32.5	$p < 0.001$
Total cholesterol			
10 - 14 year old	178.5 ± 23.8	159.6 ± 24.1	$p < 0.01$
15 - 19 year old	194.3 ± 28.6	156.6 ± 26.4	$p < 0.0001$
	Obese children (Male + Female	**Adult males in Singapore**	**Significance of difference**
Total cholesterol	191.2 ± 38.0	183.7 ± 35.7	NS
HDL-cholesterol	28.0 ± 10.5	42.7 ± 8.9	$p < 0.001$

* *Mean total cholesterol and triglyceride values for American children are from Tamir* et al[16]
\+ *Mean total cholesterol, HDL-cholesterol levels for adult males are from Saha*[18]
NS = not significant

adults it was noted that changes in body mass index was an important determinant of changes in total cholesterol and HDL-cholesterol[25].

Changes in lipid and lipoprotein levels may be more specifically related to distribution of body fat. Trunkal distribution of fat appears to be closely related to high concentrations of cholesterol fractions, low HDL-cholesterol and apolipoprotein A-I in children[26]. A significant correlation between abdominal obesity and lipoprotein or apolipoprotein levels was similarly found in adults[27-29].

The importance of evaluating serum levels of lipids and lipoproteins in obesity lies in their association with atherogenesis[30-31]. Although obese children may not have clinical manifestation of atherosclerosis and coronary artery disease, one should not ignore the possible long term development of such conditions in these individuals. The early development of coronary artery disease in childhood and adolescents has been noted in several studies[6-10]. Other workers have demonstrated the phenomenon of tracking of cholesterol, triglyceride, HDL-C and LDL-C from early childhood[32-36]. Orchard *et al*[37] found that in

Table IV
Correlation of serum lipid and lipoprotein levels of obese children with anthropometric parameters

	Correlation Coefficient		
	Weight	Relative weight	Body mass index
Triglyceride	0.13	0.13	0.14
Total cholesterol	-0.17	0.35*	0.14
HDL-cholesterol	-0.16	0.08	-0.02
LDL-cholesterol	-0.19	0.31+	0.11
VLDL-cholesterol	0.14	0.11	0.13

HDL = High density lipoprotein
LDL = Low density lipoprotein
VLDL = Very low density lipoprotein
* $p < 0.01$
\+ $p < 0.02$

children aged 11 to 14 years, 76% of those with serum cholesterol levels at the top quintile remained in the top two quintiles on follow-up nine years later.

In conclusion, it had been demonstrated that obese children in this study had significantly raised total cholesterol, triglyceride, LDL-C and VLDL-C, with decreased HDL-C levels when compared to age and sex-specific values or percentiles. There is also a tendency for lipid and lipoprotein levels to be related to degree of obesity as determined by relative weight. Further work may be done on the changes in apolipoprotein levels in obese children and also on the association of lipid profiles to distribution of fat. The effect of weight control on serum lipid and lipoproteins in children also needs to be evaluated. The clinical implications of these findings has particular relevance to the long term development of coronary heart disease.

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