The Effect of Foetal And Early Childhood Growth on Metabolic Derangements of Sri Lankan Children

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Abstract

Background

Studies have shown that accelerated postnatal growth plays a significant role on the onset of adult metabolic diseases. The aim of this study was to identify the effects of intrauterine and later growth on metabolic derangements among children in Colombo, Sri Lanka

Materials:

A school-based cross-sectional study was conducted among 5–15 year old children selected using a two-stage probability-proportionate-to-size cluster sampling technique. Birthweight (BW) was extracted from records to denote prenatal growth; and body mass index (BMI) and fat mass (FM) measured to denote the current growth of children. As metabolic parameters, fasting and random blood glucose, lipid profile and blood pressure (BP) were measured. The sample was stratified by age (5–10 years and 11–15 years); and each age group further categorized into tertiles of BW and BMI. Based on these two parameters, metabolic parameters were evaluated within each age category.

Results

The sample comprised 833 (494 boys). Metabolic parameters did not significantly differ by sex or across BW tertiles of each BMI tertile. However, significant increases were noted in all except FBS across the BMI tertiles of each BW tertile. Children belonging to the lowest BW and highest BMI tertiles had worst metabolic profiles, while those in the lowest BW as well as BMI tertile were protected. Changes were more significant in the older age category. Irrespective of BW, fat deposition rather than nutritional growth seemed to move children to higher BMI tertiles.

Conclusion

Poor prenatal growth is not the sole risk factor for abnormal metabolic profile found in childhood. Those who gain weight during early childhood are at higher risk than those who remain small. This favours the accelerated postnatal growth hypothesis.

Introduction

Growth distinguishes paediatric population from adults. Not only does it reflect the nutritional status of an individual but also determines his future health. This has given insights to the origin of non-communicable diseases (NCD) in adults and introduces new avenues in prevention of these illnesses.

Many retrospective epidemiological studies have shown the impact of early nutrition on later health [1]. Barker noted that small-for-gestational-age (SGA) individuals were the most disadvantaged as far as the development of many NCDs was concerned [1]. Their foetal as well as early-postnatal under-nutrition has been noted to have many adverse outcomes in later life with respect to blood pressure (BP), cardiovascular diseases (CVD), impaired glucose homeostasis, abnormal lipid metabolism, hepatic steatosis and even malignancy. This marked the beginning of the “foetal origin of adult diseases” hypothesis, in which under-nutrition during early life was seen as a threat for NCD.

If Barker’s hypothesis holds true, the incidence of NCDs should have been very high in many Asian and African populations for a long period of time. Instead, a rise in NCDs had become apparent only recently in many Asian countries (e.g. China,

India), and this too in the backdrop of substantial improvements of birth-weight (BW) [2]. Alternatively, this phenomenon could be well explained by the catch-up growth seen in early life.

Maternal illnesses and under-nutrition predispose the offspring to foetal under-nutrition, after which rapid postnatal growth usually follows in order to achieve “catch up growth” as early as possible. Many animal studies have shown that such an alteration in the trajectory of growth could result in adverse health outcomes. Rapid growth in pre-term children has shown to lead to many metabolic derangements such as high BP, cholesterol, insulin and leptin resistance with significant endothelial dysfunction at 16 years of age [3, 4]. Similarly, when SGA infants at-term were given enriched formula to promote catch up growth, they had shown elevated BP and increase in fat mass at 8 years of age [5]. This acceleration has also shown to lead to central adiposity in many, leading to CVD and type 2 diabetes mellitus (DM) in later life [6]. These adverse health outcomes observed with “over feeding” as opposed to under nutrition in the immediate postnatal period, led Singhal & Lucas to propose the “accelerated postnatal growth” hypothesis [3].

It is shown that there could be a period in foetal and/or early postnatal life where “programming” of growth takes place, which would begin to “track” to adult life. According to animal studies, animals that are smaller during this window will remain small and vice versa. Once tracking has established, changing the growth trajectory by offering more protein and energy may lead to storing the excess as fat, thus resulting in obesity rather than letting an individual grow with an appropriate body composition. Although animal models have shed some light on these different “biological phenomena”, applying this knowledge to humans is not always easy, as conducting nutritional intervention trials of this sort invariably give rise to debatable ethical issues. Nevertheless, there are implications at population level especially in Asian populations, where low BW cohorts are found to be more vulnerable to NCDs, in the backdrop of drastic nutritional and socio-economic transitions that have transformed the conservative Asian societies into those accumulating many NCD risk factors.

Growth is a continuous process and birth is only an incidental event in that process that changes the environment in which they grow. In line, post-natal growth needs to match its foetal growth, so that adverse programming effects are not encountered throughout. This suggests that managing growth faltering has to be done cautiously, with due consideration given to their genetic potential for growth. Such proper management of growth will yield an optimum programming effect in children, which will exert better long-term effects when applied at a critical period during early growth (prenatal or early postnatal period) [7]. This study was carried out to identify the effect of intrauterine growth (reflected by BW) and later growth (reflected by body fat and composition in early and late childhood) on metabolic derangements among 5–15 year old children in Colombo, Sri Lanka.

Method

A cross-sectional study was carried out among 5-15-year-old apparently healthy Sri Lankan children recruited from 15 state schools in the district of Colombo, Sri Lanka. They represented children studying in grades 1-10 and of mixed ethnic and socio-economic backgrounds. Those with any acute/chronic illness or on any medication, as confirmed by documental evidence were excluded. The minimum sample calculated was 790 to ensure detection of an expected proportion of children with obesity of 2%[8]; with level of precision of 0·01; confidence interval of 0·05; and a non-response rate of 5%. The sample was recruited using a two-stage, probability-proportionate-to-size (PPS) cluster sampling technique. Stratified by age and gender, one class from each grade was included as a cluster, which was randomly selected from each school that was selected according to PPS. The eligible students and their parents were informed about the procedure, and written consent from parents and assent from children were obtained. The Ethics Review Committees of the Faculty of Medicine, University of Colombo and Lady Ridgeway Hospital for Children approved the study.

Assessment of growth

During data collection, BW was extracted from the child health development record as a proxy measure of their foetal growth. As proxy measures of the current growth of children, several parameters were considered based on body mass index

(BMI), waist circumference (WC) and body fat.

Height and weight were measured using a standard protocol [9] in order to calculate the BMI (weight (kg)/ height $(m)^2$) and to identify their overweight/obesity status based on IOTF Classification. Waist circumference was measured at the midpoint between the lower border of palpable rib and iliac crest in the mid axillary line, using a non-stretchable flexible tape to the nearest 0.1cm at the end of expiration.

Total body fat mass (FM) of children was assessed using the whole body bio-impedance assay (BIA) technique using eight-electrode InBody 230 machine (Boispace Co Ltd, South Korea). This technique had been previously validated against a Sri Lanka-based BIA equation [10] and height-weight based equation [11], in which correlations of 0·95 ($p<0·001$) and 0·97 ($p<0·001$) were shown with total body water (TBW) and fat free mass (FFM), respectively. Also, when compared with assessments made by height-weight based equation, high correlations were given for both TBW ($r=0·91$; $p<0·001$) and FFM ($r=0.93$; $p<0·001$). The FM and FFM were evaluated in absolute amount (kg), as an index (FMI, FFMI kg/m^2) and as a percentage out of total fat (%FM).

Assessment of metabolic derangements

Bio-physical measurements were done as parameters to detect metabolic derangements. The BP was measured in seated position using a mercury sphygmomanometer after a 10-minute rest period. The first and fifth Korotkoff sounds were used to represent the systolic BP (SBP) and diastolic BP (DBP), respectively.

Blood was drawn after a 12-hour overnight fast to test for fasting blood glucose (FBG) and lipid profile. Oral glucose tolerance test was also done after giving a drink of anhydrous glucose 1·75 g per kg per body weight to a maximum of 75g; and blood drawn two hours later for random blood glucose (RBG).

Biochemical analysis

Biochemical analysis was performed at the endocrine laboratory of the Obstetrics and Gynaecology department, University of Colombo. Blood glucose was assessed by enzymatic spectrophotometric method using glucose oxidase and peroxidase enzymes. Quantitative analysis was done using spectrophotometer (BioSystems®). Cholesterol ester molecule was cleaved using cholesterol oxidase and peroxidase enzymes and cholesterol level was assessed quantitatively using spectrophotometer (BioSystems®). Enzymatic cleavage of triglycerides (TG) was done using glycerol phosphate oxidase and peroxidase enzymes and end-product was assessed quantitatively by spectrophotometer (BioSystems®). HDL-cholesterol (HDL-c) was measured using enzymatic spectrophotometry with enzymatic analysis using cholelseterol esterase, cholesterol oxidase and peroxidase. Quantitative assessments were done by spectrophotometer (Randox ®). LDL-cholesterol (LDL-c) was calculated using the equation (total cholesterol - (HDL-c+TG/5)). Serum insulin was assessed by **s**olid phase, enzyme-labelled chemiluminescent immunometric assay using immulite 1000 ®analyser (Siemens, USA).

Statistical analysis

Quantitative data were described using mean and standard deviation (SD) and qualitative data using proportions. The sample was stratified by age into two groups: 5-10 years and 11-15 years; and each group further categorized into tertiles of BW (denoting foetal growth) and BMI (denoting current growth). Metabolic parameters within each age category were evaluated across the BMI or BW tertiles. For this purpose, 3×3 tables were constructed and their significance assessed using ANOVA (for normally distributed variables) and Kruskal–Wallis (for non-normally distributed variables) tests at 0.05 level of significance.

Results

A total of 833 (494 boys) children were studied. Characteristics related to the growth of the children stratified by age and sex are presented in Table 1. In both 5-10 and 11-15 year age categories, the weight, BMI, FM, FMI and WC were significantly higher in girls, while FFMI was higher in boys. Birth-weight was similar in all four groups. Further, the overall prevalence of obesity was 3.2%; overweight was 9.6%; and severe wasting has been 8.9% in the study population (Table 2).

Table 3 shows the distribution of metabolic parameters of the total sample by tertiles of the current BMI and BW. Since there was no gender difference noted in relation to each metabolic parameter, both males and females were analysed together by age groups only.

In both age groups, both mean SBP and DBP did not show significant differences when compared across the BW tertiles of each BMI tertile (Table 3a and 3b). However, when compared across the BMI tertiles, BP values were significantly increasing within each BW tertile. Characteristically, the lowest SBP and DBP values of both age groups were found in the middle BW tertile of the lowest BMI tertile; and the highest BP values also in the middle BW tertile but within the highest BMI tertile.

Table 1: Demographic and growth parameters of the study population according to age category and gender

Characteristic	5 – 10 years		11 – 15 years	
	Male (N=239)	Female (n=181)	Male (n=255)	Female (n=158)
Age (years)	7.8±1.3	7.9±1.3	12.3±1.5	12.6±1.5
Birth weight	3.0±0.5	3.0±0.6	3.0±0.5	2.9±0.5
Height (cm)	124.2±8.9	125.0±9.9	146.8±11.4	148.2±9.8
Weight (kg)	23.1±6.4	24.9±8.5*	36.5±10.8	39.8±12.6*
BMI (kg/m^2)	14.8±2.5	15.6±3.3*	16.6±3.3	17.8±4.3*
Height Z-score	-0.32±1.0	-0.25±1.1	-0.71±1.1	-0.6±1.2
Weight Z-score	-0.8±1.4	-0.32±1.6*	1.5±1.6	‡
BMI Z-score	-1.02±1.5	-0.7±1.8	-1.02±1.7	-0.6±1.7*
Fat mass (kg)	4.4±3.7	6.2±4.8*	7.2±5.4	11.48.0*
Fat free mass (kg)	18.7±3.8	18.7±4.5	29.2±7.8	28.4±6.3
Fat mass index (kg/m^2)	2.8±2.0	3.7±2.5*	3.3±2.3	5.1±3.3*
Fat free mass index (kg/m^2)	12.0±1.2	11.8±1.4	13.3±1.8	12.8±1.7*
% FM	17.5±9.1	22.2±9.8*	18.7±8.9	26.2±10.8*
Waist Circumference (cm)	53.6±7.5	56.1±8.8*	61.9±9.7	64.8±10.7*

* $p<0.05$ when compared each parameter between gender groups within each age category.

‡ SD Scores are not calculated for that age group

Table 2: Nutritional status of the study population according to IOTF classification according to age and gender.

Nutritional status	5 – 10 years		> 10-15 years		Total no. (%)
	Male No. (%)	Female No. (%)	Male No. (%)	Female No. (%)	
No.	239	181	255	158	833
Obese	8 (3.3%)	9 (4.9%)	6 (2.3%)	4 (2.5%)	27 (3.2)
Overweight	14 (5.8%)	21 (11.6%)	19 (7.4%)	26 (16.4%)	80 (9.6)
Normal	88 (36.8%)	73 (40.3%)	100 (39.2%)	65 (41.1%)	326 (39.1)
Thinness					
Thinness 1	71 (29.7%)	34 (18.8%)	70 (27.4%)	27 (17.1%)	202 (24.3)
Thinness 2	36 (15.0%)	26 (14.4%)	42 (16.5%)	20 (12.6%)	124 (14.9)
Thinness 3	22 (9.2%)	18 (9.9%)	18 (7.1%)	16 (10.1%)	74 (8.9)

The mean FBS did not show any typical pattern (Table 3c) within each BW or BMI tertile. In comparison, RBS also showed the same across different BWs, but a significant increase across the BMI tertiles of each BW tertile (Table 3d). This effect was pronounced in older age group.

Both total cholesterol and LDL-c did not vary significantly either across the BW tertiles or BMI tertiles (Table 3e & 3f). However, TG in the younger age category showed significantly higher values in the highest BMI tertile of the lowest BW tertile, while in the older age group, children in the highest BMI tertile showed significantly higher TG in the middle and highest BW tertiles (Table 3g). HDL-c was highest in those in the lowest BMI and lowest BW tertile. The lowest HDL-c was seen in in the highest BW tertile of all BMI groups (Table 3h). But the HDL-c values were above the cut off.

It was also shown (Table 4) that %FM differed significantly across the BMI tertiles, with higher values demonstrated in the highest BMI tertile compared to the other two tertiles, demonstrating an almost two-fold increase across BMI. This suggests that the gain in weight (or BMI) was most likely to have occurred due to an accumulation of fat rather than a true growth with a healthy body composition.

Discussion

Our study confirms that BW in isolation would minimally affect the metabolic abnormalities related to NCD in children. Consequently, children with optimum body composition (children belonging to middle BW and BMI tertiles) were found to be metabolically healthier, denoting the role of BW on subsequent metabolic derangements. However, more importantly and contrary to the Barker hypothesis, the study further shows that, if a child is born with a lower BW but is able to maintain an optimum BMI, he too is protected from adverse metabolic derangements. This is in contrast to children born with a lower BW, followed by a higher weight gain during childhood (those belonging to lower BW and higher BMI tertiles) showing the worst metabolic outcomes. This highly suggests that BW is not the only risk factor that determines a poorer metabolic profile in children, but the weight gain during the first few years of life that has a greater contribution.

According to studies, changes in BP appear to track down from a younger age. The 1970 British birth cohort showed an inverse relationship between SBP at 10 years of age and BW [12]. When the cohort was stratified by BW and current weight tertiles, the highest mean SBP was observed among those belonging to the lowest BW and highest weight tertiles, while the lowest mean SBP was seen in the highest BW and lowest bodyweight tertiles. In comparison, the best mean SBP and DBP observed in our study were among children belonging to the middle BW and lowest BMI tertiles.

In the same British study, when children were stratified by prematurity, no difference in BP was observed [12], highlighting the greater role played by BW and subsequent weight gain in the BP of later life. Furthermore, Barker and co-workers in their 1946 British birth cohort at 36 years of age showed an inverse relationship of SBP with mothers' height, which could be considered as an indirect measure of uterine size that may contribute to birth size. This association, derived independent of maturity, led the authors to conclude that intrauterine environment influences the BP in adult life. As per this study, the control of NCDs could even be a generation long process, where a healthy girl child with good uterine size would give birth to a well-grown healthy baby.

With regards to RBG, a significant relationship was established with BW and BMI tertiles in our study. In contrast, FBG failed to show a relationship, highlighting its poor applicability as a routine screening test to detect impaired glycaemic control. In a previous study, we showed that fasting and 2-hour post glucose serum insulin levels as well as insulin resistance measured using HOMA-IR have a strong relationship with lower BW and higher current BMI [13].

Hales and co-workers studying a group of 59–70 year old men from Hertfordshire, UK showed that adults of both low BMI with poor prenatal growth helped in protecting against dysglycaemia [14]. A similar relationship was noted in relation to the current size of adults, where 2-hour plasma glucose was lower in men having both lower weight at one year and lower BMI as adults (6.6 mmol/L), compared to those with lower weight at one year but higher BMI as adults (7.7 mmol/l). The lowest 2-hour glucose was seen in those having higher BW and lower BMI as adults (5.8 mmol/L). Plasma 32–33 split pro-insulin concentration also showed a similar distribution. This denotes that weight at one year in combination with later growth is a better predictor of adverse health outcomes in later life than early weight alone.

Interestingly, a study involving 16–19 year old children in India, which reports a higher incidence of low BW, did not show significant associations between BW and metabolic derangements during late adolescence [2, 15]. However, a higher risk for coronary heart disease (CHD) and DM was seen in low BW children who were better nourished at the time than their counterparts. This study further reiterates the role played by catch-up growth.

It is shown that children with catch-up growth have a greater risk of dying from CHD later in life. According to Helsinki study, there was a 14% (95% CI = 8–19%, $p < 0.0001$) increase in this risk for each unit increase of ponderal index (kg/m^3) at birth and a 22% (95% CI = 10–36%, $p = 0.001$) increase for each unit increase of BMI at 11 years of age [16]. The highest death rates were seen in children who were thin at birth but had catch-up growth to reach normal BMI at 7 years [16]. Similarly, Harvard growth study showed the effect of high BMI at childhood on CHD in later life, which was independent of adult BMI [15]. In comparison, our data also showed that low BW children achieving a higher BMI in early life would have an adverse metabolic profile. As to the cause underlying this, accumulation of fat was strongly implicated.

Reports suggest that foetal nutrition, as denoted by BW, may have an inverse programing effect on abdominal adiposity in later life, which could contribute to the development of insulin resistance [6]. This indicates that one's body composition during foetal and early life is associated with adult disease risk [17]. Two primary mechanisms have been identified [17]. One is that poor foetal and infant growth could constrain on the development of lean body mass, thus reducing the metabolic capacity which is not able to tolerate a calorie-rich diet. The other mechanism is rapid growth in infancy and excess weight gain disproportionately diverts energy to abdominal adipose tissue, thus increasing the metabolic load.

It is shown that rapid weight gain during infancy in SGA children is associated with increased fat mass rather than lean mass [6, 18]. Early catch-up growth after SGA birth rather than SGA itself has been noted as a CVD risk factor in later life [19]. However, the tendency of SGA children to assimilate intra-abdominal fat is not yet clear; whether due to low BW itself, rapid postnatal catch-up growth or a combination of both [6, 20]. During recovery from wasting or protein-energy malnutrition in children and adults, fat mass is shown to accumulate much faster than the muscle mass. This phenomenon could partly explain the adverse outcomes in SGA children during catch-up growth [6]. Therefore, although catch-up growth explicitly confers several benefits in relation to improved neurodevelopment, enhanced immune function and achieving adult height, there are certain adverse metabolic consequences as well, such as the insulin resistance, metabolic syndrome, DM,

CVD, increased fat mass and obesity. As such, it is imperative that early feeding of SGA children requires close growth monitoring. In this regard, growth of SGA children should be monitored monthly in the first two years, with close attention paid to any upward crossing of SD lines (WHO growth references).

This paper highlights several implications for improving the clinical practice related to children in early life, especially in developing countries where poor prenatal growth of a child is still a grave issue. In such clinical settings, measures should be in place to prevent excess weight gain in SGA children. To this end, length/height of a baby, which is usually parallel to weight gain, should be assessed at 3–6 month intervals up to two years, so that growth could be evaluated with the use of length/height for weight charts. If practically possible, regular assessment of catch-up fat is necessary. Further, larger cohort studies are needed from developing countries to understand the best possible trajectory of growth based on anthropometry with the metabolically favourable body composition to prevent complications of SGA infants.

Limitations

It is not a longitudinal study and we did not have control over the birth measurements which were taken by different persons at different institutions. Definite time of acceleration of growth happened that affected these metabolic changes is not known.

Conclusions

Irrespective of birth weight, excessive weight gain in early stages of life adversely affect the metabolic profile of a child. A child with SGA should be carefully monitored for its growth and maintaining at appropriate weight to height/length is of paramount importance for favourable metabolic outcomes later in life.

Abbreviations

ALT - Alanine aminotransferase

AST - Aspartate aminotransferase

BMI - Body mass index

BP – Blood pressure

BW – Birth Weight

CHD – Coronary heart disease

CVD - Cardio vascular disease

DBP - Diastolic blood pressure

FBG - Fasting blood glucose

FM – Fat mass

FMI – Fat mass index

FFM – Fat free mass

FFMI – Fat free mass index

HDL-c - High density lipoprotein

HOMA-IR - Homeostatic model assessment of insulin resistance

hs-CRP - High sensitivity C reactive protein

IOTF – International Obesity Task Force

LDL-c - Low density lipoprotein

NCD – Non Communicable Disease

OGTT - Oral glucose tolerance test

PPS – Probability proportionate to size

RBG - Random blood glucose

SBP – Systolic blood pressure

SD - Standard deviation

SGA – Small for gestational age

TBW – Total body water

TG - Triglyceride

%FM – Percentage fat mass

WC - Waist circumference

Declarations

Ethics approval and Consent to participate

Informed written consent was obtained from parents. The Ethics Review Committee of Faculty of Medicine, University of Colombo, approved the study protocol (EC-08-065)

Consent for publication

Not applicable

Availability of Data and Material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

Authors declare that there are no competing interests.

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Author contributions

VPW conceptualized, designed, conducted the study and wrote the manuscript. **CA** analysed the data and wrote the manuscript.

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Tables

Table 3: Distribution of the metabolic parameters according to birth weight (denoting fetal growth) and BMI (denoting current growth) tertiles and age groups of children

Birth weight tertiles	5-10 year age group				11-15 year age group			
	Current BMI tertiles			Total	Current BMI tertiles			Total
	T1	T2	T3		T1	T2	T3	
	a. Systolic blood pressure (mmHg)							
T1	87.7±8.7	90.6±9.8	95.9±12.4*	91.4±10.7	97.9±9.2	103.6±10.7	109.5±10.8*	103.2±11.2
T2	85.9±9.4	90.7±8.8	97.5±11.8*	90.8±11.0	96.1±8.1	104.0±10.5	112.9±10.1**	104.1±11.6
T3	87.6±7.7	92.9±8.8	95.9±10.9*	93.1±10.0	98.2±8.2	103.9±11.3	107.6±10.7*	104.2±8.4
Total	87.0±8.8	91.5±9.2	97.1±11.6		97.6±8.7	103.8±10.8	109.4±10.7	
	b. Diastolic blood pressure (mmHg)							
T1	53.5±6.9	55.9±8.0	59.8±9.5*	56.2±8.4	60.5±7.1	64.1±8.5	67.2±7.2*	63.7±8.0
T2	52.7±7.6	55.9±7.6	60.0±9.1*	55.8±8.5	59.9±8.6	64.4±7.2	70.5±7.3*	65.2±8.5
T3	54.4±6.4	57.1±8.8	59.3±9.2	57.5±8.7	60.8±8.1	63.5±9.3	67.5±8.1*	64.6±8.9
Total	53.4±7.1	56.1±7.9	60.3±9.3		60.7±7.7	64.1±8.4	68.1±7.7	
	c. Fasting blood glucose (mg/dl)							
T1	4.37±0.45	0.44±0.51	4.37±0.49	4.40±0.48	4.53±0.45	4.53±0.33	4.53±0.56	4.53±0.46
T2	4.32±0.47	4.29±0.59	4.45±0.60	4.35±0.55	4.51±0.51	4.60±0.39	4.67±0.50	4.59±0.46
T3	4.26±0.38	4.28±0.48	4.37±0.33	4.31±0.55	4.57±0.41	4.60±0.48	4.71±0.43	4.64±0.44
Total	4.33±0.44	4.36±0.52	4.40±0.49		4.54±0.46	4.58±0.49	4.64±0.50	
	d. Random blood glucose (mmol/L)							
T1	4.86±0.83	4.91±0.82	5.11±1.03	4.95±0.89	4.74±0.78	4.95±0.78	5.17±1.14	4.93±0.93
T2	4.77±1.20	4.80±1.03	5.30±0.84*	4.73±0.94	4.77±1.20	4.80±1.03	5.32±0.84	4.95±1.05
T3	5.03±1.13	5.05±0.95	5.35±0.80	4.85±0.83	5.03±1.13	5.05±0.95	5.35±0.80	5.18±0.94
Total	4.65±0.84	4.82±0.85	5.11±0.93		4.82±0.99	4.95±0.93	5.28±0.94	
	e. Total cholesterol (mmol/L)							
T1	4.10±1.06	4.16±0.87	4.55±0.79	4.25±0.94	4.21±0.84	4.05±1.04	4.39±0.86	4.22±0.91
T2	4.39±0.85	4.29±0.89	4.30±0.94	4.33±0.89	4.06±0.84	4.03±0.93	4.18±0.96	4.08±0.91
T3	4.17±0.66	4.13±1.07	4.47±0.90	4.29±0.92	4.59±0.84	4.14±0.78	4.50±0.87	4.39±0.85
Total	4.22±0.92	4.21±0.91	4.46±0.90		4.27±0.86	4.08±0.91	4.39±0.89	
	f. LDL-c level (mmol/L)							
T1	2.36±1.09	2.47±0.86	2.89±0.85	2.54±0.97	2.45±0.87	2.48±1.06	2.74±0.87	2.55±0.93

T2	2.81±0.89	2.61±0.96	2.71±0.98	2.72±0.94	2.38±0.90	2.35±0.83	2.40±0.86	2.38±0.85
T3	3.90±0.66	2.63±0.99	2.99±0.89	2.81±0.89	2.91±0.82	2.43±0.87	2.85±0.88	2.72±0.89
Total	2.60±0.97	2.60±0.91	2.86±0.93		2.55±0.89	2.42±0.92	2.72±0.88	
	g. Triglyceride level (mmol/L)							
T1	0.72±0.26	0.79±0.26	0.94±0.46*	0.81±0.34	0.82±0.33	0.88±0.35	1.11±0.49*	0.93±0.41
T2	0.81±0.37	0.82±0.31	0.82±0.35	0.82±0.34	0.85±0.35	0.88±0.32	1.14±0.47*	0.95±0.39
T3	0.77±0.24	0.75±0.31	0.83±0.31	0.79±0.30	0.91±0.42	0.87±0.52	1.01±0.42	0.94±0.46
Total	0.76±0.30	0.78±0.28	0.89±0.39		0.85±0.36	0.88±0.41	1.08±0.46	
	h. HDL-c level (mmol/L)							
T1	1.42±0.46	1.33±0.36	1.22±0.43	1.33±0.43	1.38±0.45	1.17±0.36	1.14±0.37*	1.24±0.42
T2	1.23±0.40	1.30±0.43	1.21±0.39	1.24±0.41	1.29±0.45	1.24±0.36	1.26±0.42	0.48±0.40
T3	1.09±0.34	1.16±0.38	1.10±0.30	1.11±0.34	1.24±0.40	1.31±0.51	1.17±0.36	1.23±0.43
Total	1.28±0.43	1.25±0.40	1.18±0.37		1.32±0.44	1.24±0.42	1.18±0.38	

●significantly differ from overall mean for first and second (T1 & T2) BMI tertiles.

Significantly differ from overall mean for first (T1) BMI tertile

**significantly high ($p<0.05$) than the lowest 2 values

*significantly high ($p<0.05$) than the lowest value

Table 4: Distribution of the fat distribution according to birth weight (denoting fetal growth) and BMI (denoting current growth) tertiles and age of the children

Birth weight tertiles	**5-10 year age group**				**10-15 year age group**			
	Current BMI tertiles			**Total**	**Current BMI tertiles**			
	T1	**T2**	**T3**		**T1**	**T2**	**T3**	**Total**
T1	14.0±4.4	15.5±3.8	27.8±10.2**	18.2±9.1	14.0±4.4	16.1±7.6	32.6±10.8**	18.7±5.5
T2	13.0±3.4	16.9±3.6	29.3±10.5**	18.8±9.3	13.0±3.4	14.8±4.5	29.7±10.5**	18.0±4.7
T3	14.8±7.0	16.9±3.7	30.0±10.0**	22.5±10.4	14.8±7.0	13.3±4.1	29.3±9.3**	18.1±7.6
Total	13.3±4.9	16.6±4.2	30.1±9.9		13.3±4.9	15.1±6.3	30.6±10.2	18.3±6.1

● significantly differ from overall mean for first and second (T1 & T2) BMI tertiles.

Significantly differ from overall mean for first (T1) BMI tertile

**significantly high ($p<0.05$) than the lowest 2 values

*significantly high ($p<0.05$) than the lowest value