Childhood Obesity and Its Relationship with Selected Motor Quality and Physiological Parameters including Risk Factors for Coronary Artery Disease in 5 - 12 Years Old Boys

Thesis submitted for the partial fulfillment of the Doctor of Philosophy (Science) under Vidyasagar University

Submitted By

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CERTIFICATE FROM THE SUPERVISOR

This is to certify that the thesis entitled "Childhood Obesity and Its Relationship with Selected Motor Quality and Physiological Parameters including Risk Factors for Coronary Artery Disease in 5-12 Years Old Boys" submitted by Supriya Kumar Misra who got registered for PhD w.e.f. 01.12.2010 for the award of PhD (Science) degree of Vidyasagar University is absolutely based on his own work under my direct supervision and that neither this thesis nor any part of it has been submitted for any other degree or any other academic award anywhere before.

Date: 24.01.2017

Place: Medinipur, WB, India

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Declaration

I hereby declared that the research work presented in the thesis entitled **"Childhood Obesity and Its Relationship with Selected Motor Quality and Physiological Parameters including Risk Factors for Coronary Artery Disease in 5-12 Years Old Boys"**, has been complied by me under the supervision of Professor Chandradipa Gosh of Department of Human Physiology with Community Health, Vidyasagar University, for the fulfillment of the requirement for the degree of Doctor of Philosophy. During the experiments, I have taken my care of every effort to follow the references and subjective guidelines clearly. Whenever contributions of others are involved, I have put my best to acknowledge such collaboration and discussion.

It is also declared that, the research report and results presented in this investigation is original and has not been submitted in part or full for the award of any Degree or Diploma of any University or Institution.

Supriya Kumar Misra

Midnapore

Supriya Kumar Misra

Dedicated to

My father

Mr. Himangshu Kumar Misra

&

My mother

Mrs. Sulekha Misra

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List of Abbreviations

µl	microliter (s)
95% CI	95% Confidence Interval
ADH	Autosomal Dominant Hypercholesterolemia
ANOVA	Analysis of Variance
ApoB	Apolipoprotein B
ApoE	Apolipoprotein E
BMI	Body Mass Index
bpm	beats per minute
CAD	Coronary Artery Disease
CHD	Coronary Heart Disease
cpm	cycle per minute
CVD	Cardio Vascular Disease
DBP	Diastolic Blood Pressures
dl	decilitre (s)
ECG	Electrocardiograph
FRT	Foot Reaction Time
FTO	Obesity Associated Gene
HDLC	High Density Lipoprotein Cholesterol
Hg	Mercury
HR	Heart Rate
HRT	Hand Reaction Time
HST	Harvard Step Test

Hz	Hertz
ICMR	Indian Council of Medical Research
IHD	Ischemic Heart Disease
kcal	kilocalorie (s)
l	liter (s)
LBM	Lean Body Mass
LDLC	Low Density Lipoprotein Cholesterol
m	meter (s)
MDA	malodialdehyde
mg	milligram (s)
min	minutes (s)
ml	millilitre (s)
mm	millimetre (s)
mmol	millimole (s)
MUAC	Middle Upper Arm Circumference
PFI	Physical Fitness Index
PON	Paraoxonase
RDA	Recommended Dietary Allowances
RHT	Resting Heart Rate
RT	Reaction Time
SBP	Systolic Blood Pressures
SD	Standard Deviation
SE	Standard Error
sec	second (s)
SOM	Speed of Movement

TC	Total Cholesterol
U	Units (s)
VDR	Vitamin D Receptor
VJT	Vertical Jump Test
VLDL	Very Low Density Lipoprotein
Vo_2 max	Maximal O_2 Consumption
WHO	World Health Organization
WHR	Waist to Hip Ratio
WTR	Waist to Thigh Ratio

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Synopsis

Childhood Obesity and Its Relationship with Selected Motor Quality and Physiological Parameters including Risk Factors for Coronary Artery Disease in 5-12 Years Old Boys

Aims

The aims of this study was to find out the effect of childhood obesity on motor quality development and its relation with risk factors for development of coronary artery disease of the school going healthy Bengali boys at the age group of 5-12 years from middle socioeconomic class families.

Methods

This cross- sectional study was conducted in different urban private schools in three district towns of West Bengal in India during the period of 2012 to 2015. In the present study, initially total 1450 boys of age range 5 to 12 years were included from middle socioeconomic class Bengali families which were considered in accordance with the guidelines proposed by **Agarwal A (2008).** On the basis of exclusion criteria, finally 1036 boys were selected and data obtained from them in connection with the study. The boys were divided according to their chronological age in four groups such as 5- <7years, 7 – <9 years, 9 - <11years, 11- <13 years. Further according to WHO growth chart **(WHO, 2007)**, on the basis of BMI-age-boys Z-scores (normal weight: - 2SD > BMI Z score ≤ + 1SD, overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD) and also following the proposed guidelines of **Cole et al. (2002)** for boys, selected subjects in each age group were categorised in three subdivisions such Normal weight, Overweight and Obese.

Keeping in view the feasibility criteria and the relevance of the variables in the present study several selected anthropometric, motor quality, physiological, biochemical and nutritional parameters were studied to understand the effect of childhood obesity on motor quality development and its relation with risk factors for development of coronary artery disease. The measurements includes height, weight, body mass index (BMI), waist circumference (WC), hip circumference, thigh circumference, waist to hip ratio (WHR) and waist thigh ratio (WTR) were calculated which represent the degree obesity. On the other hand, motor quality parameters included hand reaction time (HRT), foot reaction time (FRT), speed of movement (SOM), agility, 30 meter sprint, vertical jump test and standing long jump test scores were calculated which represents the effect of obesity on motor quality development. The selected biochemical parameters included fasting serum lipids i.e., total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC) and low density lipoprotein cholesterol (LDLC). The ratio of total cholesterol to high density lipoprotein cholesterol (TC ÷ HDLC) was also calculated. Other two biochemical parameters such as fasting blood glucose and uric acid were also calculated. The selected physiological parameters included resting pulse rate, resting respiratory rate, systolic blood pressure and diastolic blood pressure and physical fitness index (PFI). The selected nutritional parameters included average daily intake of carbohydrate, protein, fat, calorie, vitamin A, ascorbic acid, vitamin D, vitamin B12, folic acid, iron, calcium and zinc.

Results

1. It was observed from the present study that the prevalence of being overweight and obesity in the selected boys were 26.83% and 17.76% respectively.
2. Body mass index, waist circumference, and hip circumference, WHR, WTR and body fat % were significantly differed from each other in three body weight categories in all age groups. There was general tendency of increasing BMI, waist circumference, hip circumference, thigh circumference and tendency of decreasing the WHR and WTR with advancement of age. All the percentile values (i.e., 5^{th},

10th, 25th, 75th, 90th and 95th) of BMI, body fat%, waist circumference were found to be higher in obese category than in normal weight and overweight category.

3. The present study also reveals that the mean values of HRT, FRT, SOM, agility, 30 meter sprint were significantly lower in normal weight category than in overweight and obese category in same age specific strata. On the other hand, mean values of VJT and SLJT were significantly higher in normal weight category than in overweight and obese category. In contrary, mean values of VJT and SLJT were significantly higher in overweight category than in obese boys in all selected age group. It is also observed from the study that there was general tendency of decreasing HRT, FRT, and SOM, agility, sprint and tendency of increasing VJT and SLJT with progression of age in each body weight category.
4. Present study also demonstrated that all the selected percentile values (the 5th, 10th, 25th, 75th, 90th and 95th) of VJT and SLJT to be higher in normal weight category than in overweight and obese category in same age groups. In contrary, all selected percentile values of HRT, FRT, SOM, and agility were found to be higher in normal weight category than in overweight and obese category in same age groups.
5. It is also evident from the present study that there existed significant and negative correlation between age with HRT, FRT, SOM, agility and 30 meter sprint. On the other hand, age had significant and positive correlation with the VJT and SLJT. Conversely, in multiple regressions analysis it was found that there were independent negative relationship age with selected time related motor quality parameters and also age had independent positive association with VJT and SLJT.
6. Present study also reveals that the reaction time was positively correlated with the BMI, body fat percentage, WHR and WTR. On the other hand, VJT and SLJT

values had significant and negative correlation with the BMI, fat percentage, WHR and WTR.

7. The multiple linear regression coefficient β showed that WHR, WTR had independent positive relationship with time related motor quality parameters but significant and negative correlations were found in case with VJT and SLJT.
8. Mean values of resting respiratory rate and resting pulse rate were significantly lower in normal weight category when compared with the overweight and obese category in same chronological age groups. On the other hand, mean SBP and DBP were significantly higher in overweight and obese category than in normal weight category in all age groups. It was also observed from the study that there was general tendency of decreasing pulse rate, respiratory rate and tendency of increasing SBP and DBP with advancement of age in every body weight category.
9. It is also noted from the study that the highest (95^{th}) percentile values of pulse rate and respiratory rate were higher in obese category than normal weight and overweight category. Lowest (5^{th}) to highest (95^{th}) percentile values of SBP and DBP were found to be higher in obese category than in normal and overweight category.
10. The present study also reveals that there were negative correlation between age with respiratory rate, pulse rate respectively and positive correlation with SBP and DBP. On the other hand, BMI and fat percentage were negatively but not significantly correlated with the respiratory rate and pulse rate. Conversely, WHR and WTR had significant positive correlation with the respiratory rate, pulse rate, SBP and DBP. Moreover, body mass index and body fat percentage each had significant and positive correlation with SBP and DBP.

11. In multiple linear regression analyses the age had independent negative significant relationship with the respiratory rate, pulse rate and independent significant positive relationship with SBP & DBP.
12. Multiple linear regressions analyses also showed that even after controlling the effect of age and body fat percentage, BMI had independent significant positive relationship with the SBP and DBP. On the other hand, in multiple regression analysis, 'standard partial regression coefficient' showed the independent positive relationship WHR with pulse rate, respiratory rate, SBP, and DBP.
13. It is also evident from the present study that mean values PFI scores were significantly higher in normal weight boys when compared with the overweight and obese category in 11- <13 years age group. The present study also reveals that there were significant negative relationships of BMI and body fat percentage with physical fitness index scores. Conversely, WHR and WTR were negatively associated with the physical fitness index. In multiple regression analyses showed that BMI had independent significant negative relationship with physical fitness score.
14. The present study also reveals that the mean values of serum total cholesterol (TC) were significantly higher ($p < 0.05$) in overweight category than in normal weight category in similar age group. On the other hand, mean values triglycerides (TG) were significantly ($p < 0.05$) higher in obese boys than in normal weight boys. Moreover, mean values of LDLC were significantly higher in overweight and obese weight category when compared with the normal weight category in same chronological age group. In contrast, TC: HDLC ratio was significantly higher ($p < 0.05$) in overweight and obese category than in normal weight category in all age groups except with the 5 – < 7 years age group.

15. It is evident from present study, the mean values of blood glucose were significantly higher in overweight and obese category when compared with the normal weight category in all age groups except in 5 – <7 years age group. On the other hand, the mean values of serum uric acid were significantly ($p < 0.05$) higher in obese boys than in normal weight boys in 9 – <11 years & 11 – <13 years age group. It is also observed from present study that there were general tendency of increasing the TC, TG, LDLC and TC: HDLC ratio with advancement of age.
16. Lowest (5^{th}) and highest (95^{th}) percentile values of TC, TG, LDLC and TC to HDLC ratio were found to be higher in obese category than in normal weight category in all age groups. Also lowest (5^{th}) and highest (95^{th}) percentile values of blood glucose and uric acid were found to be higher in obese category than in normal weight category in all age groups.
17. The present study showed that there existed significant positive correlations of age with lipid profile, blood glucose and uric acid. On other hand, the correlation of BMI and body fat % with TC, TG, LDLC, TC: HDLC, blood glucose and uric acid were positively associated. Conversely, BMI and body fat percentage were negatively correlated with the HDLC. On the other hand, WHR had positive correlations with the TC, TG, LDLC, and TC: HDLC and blood glucose but negative correlation was found with the HDLC. WTR was negatively correlated with the HDLC. In contrast, SBP and DBP were significantly and positively correlated with the TC, TG, LDLC, and TC: HDLC and blood glucose. On the other hand, SBP & DBP were negatively correlated with the HDLC.
18. In multiple linear regressions analyses age had independent significant and positive relationship with the TC, LDLC, and TC: HDLC, blood glucose and uric acid. On the other hand, in multiple regressions analyses also showed that even after

controlling the effect of age and body fat percentage, BMI had independent significant positive relationship with the TG, blood glucose and uric acid. Moreover, multiple analyses showed that fat% had independent positive relationship with the LDLC

19. Multiple analyses demonstrated that even after controlling the effect of age, WHR had strong significant impact on lipid profile. Therefore, the WHR and WTR may the best obesity markers for the variability of the lipid profile in this population.
20. The present study also reveals that the mean values of carbohydrate, fat and total calories were significantly higher in overweight and obese category than in normal weight category in all age groups. On the other hand, mean values of protein were significantly higher in normal weight category than obese category. In contrast, among micronutrients, the absolute intakes of vitamin A, vitamin D, calcium and zinc were lower than recommendations (RDA) in all weight category in all age groups except in 5 – <7 years age group.
21. The present study also showed that there was positive significant correlation of SBP and DBP with different nutrient intake. On the other hand, SBP and DBP were negatively correlated with the calcium intake.
22. It is evident from the present study that BMI and body fat percentage had significant positive correlation with different nutrient intake but BMI and body fat percentage were negatively correlated with Vitamin D and iron.
23. Present study also evident that there were significant negative correlation between times related motor quality parameters with different nutrient intake. On the other hand, length related motor quality parameters were positively correlated with nutrient intake.

24. The present study also reveals that the selected coronary artery risk factors (TC, TG, HDLC, LDLC and TC: HDLC) are highly prevalent among boys in overweight and obese category. Additionally, the prevalence of fasting serum uric acids and blood glucose levels were also higher in overweight and obese boys.

Conclusion

From this study it can be interpreted that BMI, waist circumference, thigh circumference, WHR and WTR remarkably high due to higher level of body fat percentage in overweight and obese boys. Higher level of BMI and body fat percentage has a negative effect on motor performance skill. This study has also demonstrated that prevalence of overweight (26.83%) and obesity (17.76%) exists in urban school going children in West Bengal in India. Prevalence of obesity is increased due to intake of high-calorie rich foods with little quantity of vitamins, micronutrients, mineral and less physical activity. From the present study demonstrated that among the anthropometric indices, BMI and body fat percentage had a significantly correlation with all lipid profile. It was also observed that waist hip ratio is partly good determinant of abnormalities in lipid profile. Our present study also showed that central obesity marker WHR is partially good predictor of blood sugar and uric acid abnormalities. Thus, the inclusion of measurement of TC, TG, HDLC, LDLC, blood sugar and uric acid levels in the assessment protocols for obese or overweight children in order to verify possible complications of early cardiovascular disease and type 2 diabetes.

The information obtained from this study can therefore be used in the set of intervention programmes for school children in 5 - 12 years of age. Future studies require employing a longitudinal design to completely recognize the composite relations of obesity related health hazards in 5 to 12 years old Bengali boys. This should include identification of children who are, or who are at risk of becoming, obese. A healthy diet should be followed by the child and family. Education regarding nutrition and developing healthy eating and lifestyle habits should be the focus. Children should be encouraged to participate in different sports related activities. Health-promotional physical fitness is negatively affected to a great degree in children between the ages of five and twelve years who are overweight and obese.

Introduction

Chapter I

1.1. General Introduction

Obesity is recognized as a major global burden to health of children **(WHO, 2000**). The rate of childhood obesity has tripled in the past two decades, and it appears to be worsening at an accelerating rate. Several cultures hold the faith that being overweight is a sign of health and wealth. The reality is, being overweight or obese increases person's risk of many chronic disease and children are no exception (**Chinese community Health Resources Center, 2006**). The ages between 3 and 10 years are high risk years for developing obesity. Adiposity rebound describes the inflection point between declines BMI and an increasing BMI that occurs between age 5 and 7 years **Bray (2008)**.The earlier rebound occurs, the greater the risk of overweight later in life. About half of overweight grade-school children remain overweight as adults and the risk of overweight in adulthood is at least twice as greater for overweight children as for non- overweight children **Bray (2008)**.

Generally accumulation of excess fat in the body is termed as obesity which has adverse effects on health. It is an abnormal growth at the adipose tissue due to an enlargement of fat cell size (hypertrophy obesity) or a combination of both **(Hager, 1981)**. The term 'overweight' means a weight in excess of the average for a given sex, height of age. Overweight usually due to obesity but can arise from other causes such as abnormal muscle development or fluid retention **(Aykroyd & Mayer, 1968).**

As individuals from both developed and developing countries consume more and more quantities of high energy food and have less physical activity, the number of overweight and obese individuals increases to epidemic proportions **(WHO, 2002)**. Different factors contributing to the development of childhood obesity are increased intake of high calorie foods with little quantity of vitamins, micronutrients, mineral and less physical activity

(**Kausik et al., 2011)**. Video games, internet, television watching are the main underlying reasons of the physical inactivity for most children in developed and developing countries also. The children in developing countries like India suffering from double form of malnutrition. Urban and semi-urban children's are afflicted with troubles of over-nutrition while rural and slam children suffer from under nutrition **(Chatterjee et al., 2002)**. The increasing prevalence of overweight, obesity and its consequences prompted the world Health Organization to designate obesity as a global epidemic **(WHO, 1998)**. The problem of obesity is confined not only in adults but also to children and adolescent **(Kapil et al., 2005)**. Obesity in children is gradually becoming a Public Health problem in many developing countries also **(Popkin, 1994)**.

Various studies from India also showed the increase prevalence of obesity. Results of a study from Punjab revealed that children in the age group of 11 -17 years residing in urban areas were more overweight (11.6%) compared to children from rural areas (4.7%), **(Kapil et al., 2005)**. A cross-sectional study carried out on 2008, school children of age 9 – 15 years in Punjab, revealed the overall prevalence of obesity and overweight was 11.1 % and 14.7 % respectively **(Chhatwal et al., 2004)**. A study conducted by the nutrition foundation of India found 29 % overweight among 5000 children aged 4 – 18 years in a Delhi Private school (**Chatterjee, 2002)**. Another study on 707 children in the age group of 10 – 15 year at Chennai revealed that 10 % of the subjects were overweight and 6 % of them were obese **(Subramanyam et al., 2003)**.

The several studies done in different parts of India from 2007-2012 demonstrate a increasing trend in the prevalence of overweight and obesity in children and adolescents (**Sharma et al., 2007; Kotian et al., 2010; Khadilkar et al., 2011; Chakraborty et al., 2012).**

Stature, body mass index, various skinfold thicknesses and other body dimensional measurements have internationally been established as perceptive indicators of growth and health status of children **(Chatterjee et al., 1993)**. BMI is most easily assessable parameter, for categorizing children as obese in age-gender- specific pattern **(Cole et al., 2002**). Children with BMI ≥ 95th percentile are obese and those with BMI ≥ 85th percentile but < 95th percentile are defined overweight and are threat for obesity associated co-morbidities (**Donohoue et al., 2004)**.

Childhood obesity is related with a number of risk factors for the development of coronary heart disease and chronic problems such as hyperlipidemia, abnormal glucose tolerance, hypertension, orthopaedic problems, and obstructive sleep apnea, asthma, psychosocial problems, certain forms of cancer etc **(Li et al., 2004; Kuczmarski et al., 2000)**. In addition to health problems, obesity is associated with poorer motor control, cognition and altered brain plasticity.

Childhood obesity is also related to the reduced cognitive functions such as attention, executive function, mental rotation, reading achievement and mathematics (**Davis & Cooper, 2011; Cserj´esi et al., 2007; Jansen et al., 2011; Lokken et al., 2009)**. Obese children also have difficulty in postural coordination and increased dependency on vision to control locomotion which is quite automatic in normal weight children (**D'Hondt et al., 2008; D'Hondt et al., 2011**). Poorer posture and walking is associated with the excessive fat mass **(Ponta et al., 2014)**. Muscle quality ratio related with the adiposity that is associated with the peroneal nerve motor conduction velocity, memory performance and finger tapping speed **(Moore et al., 2014).** Subcutaneous fatness can account for a significant variance of health-related motor fitness **(Malina et al., 1995**).

The prevalence of overweight and obesity has significantly increased in the paediatric population, warning against a worldwide epidemic. This is alarming, because metabolic changes and the consequences of obesity, formerly observed only in adults, are now observed in younger individuals **(Styne, 2001).** The potential risk factor for a child becoming obese is the frequency of obesity among family members, including genetic and environmental factors such as eating habits, which determine energy intake and the family's lifestyle **(Wang, 2002)**.

To assess the coronary artery disease fasting lipid profile such as total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density lipoprotein cholesterol (LDLC) are useful indicators. It is well established that the cardiovascular disease is the cause of morbidity and mortality for both male and female in most developed countries and also be developing countries like India.

Strong and his colleagues in **1992** reported that the atherosclerotic process begins in childhood and progresses through adulthood. Obesity in children and adolescents are at range of health problems such as psychosocial, orthopaedic, gastrointestinal, metabolic abnormalities etc. Risk factors during childhood such as elevated cholesterol and increased BMI have been shown to increase risk of CHD and stroke in adulthood, as well as cause early signs of atherosclerosis **(Baker et al., 2007**).

In case of adult, obesity emerges as a significant health risk factors associated with coronary artery disease, hypertension, type 2 diabetes, and stroke and in some cases cancer. From the study of Freedman **et al**., in **2001** it appears that the three stages of growth may be critical for the development persistent obesity that influences the co-morbidities in adulthood: the prenatal period, the period of adiposity rebound, (ages 4-8) and adolescence. The ages between 3 and 10 are high risk years for developing obesity

(**Bray, 2007**). Preventing overweight and obesity in childhood may prove highly strategic for tackling these prevalent non communicable diseases of adulthood.

Dyslipidemia or, abnormal levels of blood lipids such as hypercholesterolemia begins in childhood and adolescence and can lead to premature atherosclerosis **(Kwiterovich, 2008; Kavey et al., 2003)**. Bogalusa Heart Study Autopsy studies showed that High total cholesterol (TC), low density lipoprotein cholesterol (LDLC) and low high density lipoprotein cholesterol (HDLC) are associated with increasing coronary artery lesions **(Bao et al., 1996; Li et al., 2003).** It is known that not only in adults but also in children and adolescents; dyslipidemia is related with other cardiovascular risk factors such as hypertension and obesity **(McGill et al., 2001; Juonala et al., 2008)**.

Epidemiological studies have shown a higher incidence of cardiovascular diseases in populations with high levels of total cholesterol and of LDL-cholesterol, and with low levels of HDL-cholesterol **(Webber et al., 1995; Freedman et al., 1999)**. A study with obese children and adolescents, with a median age of 11 years and 10 months for boys and 10 years and 9 months for girls, showed abnormal HDL values in (68.75%) of the patients and a high incidence of elevated triglyceride (35%) and VLDL (37%) levels **(Valverde et al., 1999).**

There is a paucity of studies concerning the prevention of obesity and dyslipidemia, and on the markers of lipid peroxidation, especially in children and adolescents. However, when complications of obesity are already established, as in coronary artery diseases, positive correlations are observed between markers of lipid peroxidation (MDA), total cholesterol and triglycerides (TG), and negative ones are noted with HDL **(Mahapatra et al., 1998).**

LDL oxidation may be present in specific phospholipids targets on the particle surface (the so-called “minimally oxidized LDL”) or cause lipid and protein oxidation inside the particle. Consequently, there is a build-up of by products such as malondialdehyde (MDA), considered to be a marker of oxidation. Thus, oxidized LDL turns macrophages into foamy cells and also increases adhesion, activation and migration of monocytes, resulting in the formation of atheromatous plaques (**Ross, 1993).**

Uric acid at normal plasma levels has been known to exert a neuroprotective effect by acting as a free-radical scavenger; however, several observational studies have indicated that high levels of serum uric acid are associated with the risk of cardiovascular disease and may be useful in the assessment of individual cardiovascular risk. Furthermore, high uric acid levels have also been associated with insulin resistance (IR), diabetes mellitus type 2 (DM2), and metabolic syndrome **(Barbosa et al., 2011; Serpa et al., 2011).**

Among these cardiometabolic alterations, metabolic syndrome has been stressed, as it represents a set of risk factors, which consists of alterations in the metabolism of carbohydrates-hyperinsulinemia, insulin resistance, glucose intolerance or diabetes mellitus type 2, lipid metabolism alterations (increased triglycerides (TG) and/or decreased cholesterol bound to high-density lipoprotein (HDL), abdominal obesity, and high blood pressure **(Grundy et al., 2004**).

Despite evidence that uric acid is considered a cardiometabolic risk factor **(Chen et al., 2007)** there is no reference in the literature to the association between this biochemical variable and steatosis in the paediatric population, especially among obese or overweight children and adolescents.

Body shape is frequently assessed in epidemiological studies in adults to predict risks of mortality and other adverse health outcomes such as risk for development coronary artery disease (**Cerhan et al., 2014; Gonzalez et al., 2010)**. In addition to overall body weight-for-height (body mass index (BMI)), those studies often also assess measures of central body shape (for example, waist and hip circumferences, waist–hip ratio and regional fat mass distribution), which reflect the characteristic sexual dimorphism in body shape and body fat distribution **(Taylor et al., 2010; Ujcic-Voortman et al., 2011; Wells et al., 2007)**. Men have relatively more central fat ('android' distribution) while women have relatively more peripheral fat ('gynoid'), a difference which is explained by sex hormone actions.

In contrast to convincing evidence in adults that waist circumference and BMI combine synergistically to predict later disease risks **(Langerberg et al., 2012)** the added value of estimating central body shape in children is less clear. Four studies have assessed the contribution of waist circumference to cardiovascular disease risk factors in children; only one (a study of 154 overweight or obese girls aged 5–16 years) reported a positive association between waist circumference and fasting insulin resistance that was independent of BMI **(Maffeis et al., 2003)**. Others three studies were population based (sample sizes were 436, 5235 and 7589 children aged 7–12 years) and reported no additional contribution of waist circumference beyond BMI alone **(Garnett et al., 2007; Lawlor et al., 2010; Falaschetti et al., 2010).**

On the other hand, heart rate (HR) is an easy to measure but important indicator of cardiovascular health. Though the heart rate dynamics during and after cessation of exercise have been used extensively as markers of cardiovascular health, it is only in the past few years that resting heart rate (RHR) has gained attention as a simple but powerful marker of cardiovascular health **(Palatini & Julius, 1997**). A number of studies have linked an increase in resting heart rate to increased incidence of cardiovascular and non cardiovascular mortality **(Fox et al., 2007; Barrios et al., 2007).**

Obese people tend to have increased resting heart rate as autonomic responsiveness has been shown to diminish in obese individuals **(Helmreich et al., 2009) .**This could lead to a reduced ability in the obese to adapt to environment. Obesity is a major health problem affecting young and old throughout the world and is associated with a number of cardiovascular diseases and metabolic syndrome. Thus obesity is leading directly or indirectly to increased morbidity and mortality **(Obesity, WHO Technical Report, 2000)**.

Hypertension is the most common, most potent universal contributor to cardiovascular mortality. Elevated blood pressure, labile or fixed, systolic or diastolic, at any age, in either sex is a contributor to all forms of cardiovascular diseases **(Kannel et al., 1975).** Studies on hypertension in childhood have the important advantage that they may help in the control and possibly prevention of high blood pressure before its harmful sequelae can occur.

Obese patients tend to have higher respiratory rates and lower tidal volumes and total respiratory system compliance is reduced for a variety of reasons **(Birng et al., 1999).** Airway resistance is usually increased in obese individuals, and this is at least partly related to the lower lung volumes at which obese patients normally breathe, leading to closure of the smaller airways **(Zerahet al., 1993; Rubinstein et al., 1990; Ray et al., 1983; Watson & Pride, 2005)** The connection of childhood obesity to adulthood diseases is of major concern **(Chatterjee et al., 2006)** since it is harder to treat obesity in adults than in children **(Park & Park, 2005)**. So, effective prevention of adult diseases due to obesity will require the prevention and management of childhood obesity **(WHO, 2000).**

On the other hand, physical activity plays an important role in obesity control because it alters the balance between caloric intake and expenditure **(Raistenskis et al., 2016).** Studies show that the most important role in obesity control is played by physical activity:

moderate to-vigorous intensity physical activity and reduction of screen-focused sedentary time. Physical activity is positively associated with motor skills and aerobic fitness in children. Through aerobic fitness, physical activity is positively linked with the risk reduction of chronic diseases and metabolic syndrome **(Burgi et al., 2011; Dencker et al., 2010; DuBoss et al., 2007)**.

Children who are overweight but participate in physical activities that positively impact physical fitness may have fewer metabolic syndrome risk factors compared to children who are overweight but do not engage in activities that improve physical fitness **(DuBoss et al., 2007)** . Studies show that low amounts of physical activity, high total body fat, abdominal fat, and body fat distribution are related to higher composite risk factor scores for cardiovascular disease in children **(Tanha et al., 2011; Dencker et al., 2012).** Regular moderate-to-vigorous physical activity can lead to improvements in cardiorespiratory fitness at any age **(Raistenskis et al., 2016)**.

It is confirmed that obesity occurs when energy intake exceeds energy expenditure, suggesting a proper diet and physical activity are the key strategy for controlling the current epidemic of obesity **(Dehghan et al., 2005**). When controlling for body mass, obese children were found less physically active than their non-obese peers **(Huttunen et al., 1998).**

The increased prevalence of overweight and obesity in Indian children may be attributed to decreasing activity, increasing food energy intake, or a combination of these factors. Some studies have suggested that the increased incidence of obesity could be the result of an increase in the consumption of foods that are high in fat **(Danforth, 1985; Prentice, 1994**). There is no published data on the relationship between overweight or obesity, and dietary intake or physical activity, in Indian children and adolescents. On the other hand, good quality nationally representative data are still lacking, studies have generally reported a substantial rise in prevalence of childhood obesity in both urban and semi-urban population. Health risk associated conditions are possibly related with the physical health profile of overweight and obese children. These health risk factors are associated with overweight and obesity in children that resists physiological action. It is important to determine the effect of obesity on physical fitness in terms of motor quality development, and influence of obesity certain physiological, biochemical marker that associated with coronary artery disease (CAD).

1.2. Objectives of the study

The main aims of this study was to find out the effect of childhood obesity on motor quality development and its relation with risk factors for development of coronary artery disease of the school going healthy Bengali boys at the age group of 5-12 years from middle socio -economic class families. Considering this, the objectives of this study were:

1. To understand the effect of obesity on motor quality development in the above mentioned group of boys.

2. To understand the influence of obesity on certain physiological parameters in these boys.

3. To study the effect of obesity on certain important risk factors for development of coronary artery disease in these boys.

4. To study the nutritional status of these subjects and its relation to the obesity parameters and certain risk factors for coronary artery disease.

1.3. Significance of the study

The present study may be providing an idea about effect of obesity on motor quality development and relationship of obesity with certain risk factors for development of coronary artery disease. Keeping the above views in mind the significance of the present study may be as follows

1. The findings of the present study may give a comprehensive idea about motor quality development i.e., hand reaction time, foot reaction time, speed of movement and agility etc. of normal weight, overweight and obese school going boys of 5 – 12 years of age of Indian origin.

2. The present study may also be helpful in developing ideas about effect of obesity on motor quality development.

3. The present study may throw light upon the influence of obesity on certain physiological parameters i.e., pulse rate, respiratory rate and blood pressure.

4. It is expected that the results of the present study will provide information about prevalence of coronary artery disease of these boys.

5. The present study may be helpful to know the relationship of obesity with dietary intake.

Review of Literature

Chapter II

2.1. Introduction

Childhood obesity has reached epidemic proportion in both developed and developing countries **(Wang & Lim, 2012; Gupta et al., 2012)**. India is a developing country, currently undergoing major nutritional, epidemiological, and demographic transitions. These transitions tend to promote obesity in population including children. In India, the prevalence of childhood obesity has risen in recent years. **Khadilkar et al. (2011)** reported on affluent Indian two to seventeen years old children and showed that the prevalence of obesity to be 18.2% by the IOTF (International Obesity Tusk Force) criteria while it was 23.9 % using WHO cut off points and the prevalence was higher in boys. This increase was attributed to changes mainly in food habits and lifestyle factors.

Overweight and obesity in childhood are known to have significant impact on both physical and mental health. Overweight and obese children are likely to stay obese intoadulthood and more likely to develop non-communicable diseases like diabetes and cardiovascular diseases at a younger age **(Sahoo et al., 2015; Ghosh, 2014; Nawab et al., 2014).** The mechanism of obesity development is not completely understood. It is believed to be a disorder with multiple causes. Environmental factors, food habits, lifestyle preferences, and cultural environment play vital roles in the increasing prevalence of overweight and obesity worldwide. In general, overweight and obesity are assumed to be the results of an increase in calorie and fat intake. On the other hand, there are many supporting evidences that excessive sugar and fat containing food intake with physical inactivity have been playing major roles in the rising rates of overweight and obesity all around the world **(Sahoo et al., 2015).** Childhood obesity can profoundly affect children's social, physical and emotional health. It is also associated with poor academic, motor performance and a lower quality of life experienced by the child. Childhood obesity is associated with the development of a number of co-morbidities including cardiovascular, metabolic, musculoskeletal, neurological, psychosocial, hepatic, endocrine, metabolic, pulmonary, and renal disorders are also seen in association with obesity.

2.2. Definition of overweight and obesity in children

Obesity is defined as a condition of excess body fat which creates increased risk for morbidity and premature mortality.

In adults, body mass index (BMI) is a common method of assessing whether an individual is obese and the definitions of obesity and overweight are agreed. A body mass index (BMI) of greater than 25kg/m^2 is defined as overweight and a body mass index (BMI) of greater than 30kg/m^2 is defined as obese.

However, for children and adolescent (under the age of 18 years), no such absolute consensus exists **(Ruxton, 2004)** and BMI derived from weight and height must be interpreted using percentile measures **(Kaur et al., 2003).** In US children, since 2010, childhood obesity is defined as a body mass index (BMI) above the 95th percentile for age and sex (and >85th percentile for overweight), however there is a wide range of reference BMI charts available **(Ogden et al., 2010).**

The most commonly used reference for childhood overweight and obesity in India is as mentioned by **Cole et al. (2000)** and further adopted by WHO (i.e., overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD) (**WHO, 2007).**

2.3. Factors influencing overweight and obesity in children

The cause of overweight and obesity in children is thought to be a complex dynamic of the balance between energy intake and expenditure in the context of an individual's environment, behaviour and genes **(Kimm, 2003; Balaban & Silva, 2004**). The connection between genetics and environmental factors in obesity in children are particularly difficult to disentangle from one another because children often have similar eating habits and approaches to physical activity as their parents **(Oliveria et al., 1992; Nguyen et al., 1996).** On the other hand, age, heredity, sedentary life style, nutritional factors, phycho-social factors, socioeconomic and ethnic factors play vital role for development of overweight and obesity.

2.3.1. Sedentary life style

A sedentary life style lowers energy expenditure and promotes weight gain in children. In affluent society, energy spearing devices in the workplace and at home reduce energy expenditure and may enhance the tendency to gain body weight. In children there is a graded increase in body mass index as the number of hours of television watching increases **(Reilly et al., 2003**). **Graf et al. (2004)** recommended early intervention to support exercise and movement and **Moore et al. (2003)** suggested that interventions to increase children's activity level begun as early as four years of age may be helpful in preventing obesity.

2.3.2. Nutritional factors

Diet apparently has a cardinal effect on the development of obesity. The amount of energy intake relative to energy expenditure is the central reason for the development of obesity. Epidemiological data suggest that a high fat diet is associated with developing obesity. High in energy-dense, high fat and low-fibre food with high intakes of fast food has been shown to be associated with obesity in children **(Ambrosini, 2014).**

2.3.3. Obesogenic environment

The term obesogenic environment has been coined to characterised constellation of factors in the modern environment that contribute to weight gain. Obesogenicity ensues from any influence that contributes to a relative increase in energy intake or a relative decline in energy exependiture. Weight gain and eventually obesity result whenever habitual energy intake exceeds habitual energy expenditure **(Swinburn & Egger, 1999).**

2.3.4. Social factors

Social factors have also been found to influence the development of obesity. In our society there are trends to use food as a reward, as a means to control others, and as part of socializing **(Budd & Hayman, 2008).** These uses of food can encourage the development of unhealthy relationships with food and thus increasing the risk of developing obesity.

2.3.5. Family factors

Family factors have been associated with the increase of cases of overweight and obesity. The types of food available in the house and the food preferences of family members can influence the foods that children eat. In addition, family mealtimes can influence the type of food consumed and the amount thereof. Family habits, whether they are physically active or sedentary active, also influence the child **(Budd & Hayman, 2008).** Studies have shown that having an overweight mother and living in a single parent household are associated with overweight and childhood obesity **(Moens et al., 2009).**

2.3.6. Genetic factors

With recent developments in molecular biology, genetics has emerged as a new factor that is involved in the pathogenesis of childhood obesity, particularly regarding the association between single nucleotide polymorphisms of candidate genes and specific diseases **(Bouchard, 2009**). **Manco and Dallapiccola** in **2012** summarised 20 genes are associated with an increased body mass index (BMI) in paediatric populations. Among them, fat-mass and obesity-associated (FTO) gene has been most vigorously investigated, and a meta-analysis of the association between SNPs of FTO and risk of obesity in childhood has confirmed the role of FTO in the development of childhood obesity **(Liu et al., 2013).**

2.4. Consequences of Childhood Obesity

The complications of childhood obesity can be classified as psychosocial and medical consequences.

2.4.1. Psychosocial consequences

Anxiety and depression factors in the development of obesity are widely recognized, although attempt to define a specific personality type that causes obesity have been unsuccessful. A recent review concluded that the majority of studies find a prospective relationship between eating disorder and depression **(Rawana et al., 2010)**. However, this relationship is not unidirectional; depression may be both a cause and a consequence of obesity **(Goldfield et al., 2010).** In a clinical sample of obese children, a higher life-time prevalence of anxiety disorders was reported compared to normal weight **(Britz et al., 2000).** Although some studies reported no significant relationship between increased BMI and increased anxiety symptoms **(Tanofsky et al., 2004)**.

So, the relationship between obesity and anxiety may not be unidirectional and is surely not conclusive. Research findings comparing overweight/obese children with normal-weight children in regards to self-esteem have been mixed **(Zametkin et al., 2004).** Some studies have found that obese children have lower self-esteem while others do not **(Ackard et al., 2003; Jansen et al., 2008; Renman et al., 1999)**.

There is some consensus in the literature that the global approach to self-esteem measurement children who are overweight/obese is misleading as the physical and social domains of self-esteem seem to be where these children are most vulnerable **(Schwimmer**

et al., 2003). Individuals who were obese in childhood are more likely to have poor body image, and low self-esteem and confidence, even more so than those with adult onset obesity, as mid-childhood is the critical period of development of body image and self esteem **(Stunkard et al., 1967).**

Traits associated with eating disorders appear to be common in adolescent obese populations, particularly for girls **(Lundstedt et al., 2006).** A number of studies have shown higher prevalence of eating-related pathology (i.e. Bulimia Nervosa, Anorexia, and impulse regulation) in obese children or youth **(Decaluwxe et al., 2003).** In one of the few studies to investigate the psychological impact of being overweight or obese in children, a review of 10 published studies over a 10-year period (1995-2005) with sample sizes greater than 50 revealed that all participants reported some level of psychosocial impact as a result of their weight status **(Cornette, 2008)**. Being younger, female, and with an increased perceived lack of control over eating seemed to heighten the psychosocial consequences.

2.4.2. Medical consequences

Medical consequences can be broadly classified into mechanical, metabolic, pulmonary neurological, endocrine and renal complications. The main mechanical complications are obstructive sleep apnoea syndrome and orthopaedic problems such as valgus and genu varus deformity of the knees, Blount's disease and slipped capital femoral epiphysis, forearm facture, impaired balance (**Dietz et al., 1982; Loder et al., 1993; Goulding et al., 2001).** Childhood obesity has been linked to numerous metabolic, renal, endocrine, neurological complications. These complications include, but are not limited to, glucose intolerance, hypertension, non alcoholic fatty liver disease, precocious puberty, polycystic ovarian syndrome, gallstone, Type 2 diabetes, asthma, cardiovascular disease, high cholesterol, insulin resistance, steatohepatitis, skin conditions, menstrual abnormalities, pseudotumour cerebri, glumerulosclerosis , coagulaopathy, Chronic inflammation (**Balcer et al., 1999; Figueroa et al., 2001; Adelman et al., 2001; Niehoff et al., 2009; Ebbelling et al., 2004; Kaplowitz et al., 2001**; **Freedman et al., 1999; Ferguson et al., 1998; Troiana et al., 1995**; **Rawana et al., 2010**, **Goldfield et al., 2010).** Until recently, many of the above health conditions had only been found in adults; now they are extremely prevalent in overweight and obese children.

Although most of the physical health consequences associated with childhood obesity are preventable and can disappear when a child or adolescent reaches a healthy weight and some continue to have negative consequences throughout adulthood. In the worst cases, some of these health conditions can even result in early death.

2.5. Motor ability and motor quality development

The ability of performing physical activity is named physical fitness or motor fitness, although these terms are difficult to define **(Gallahue, 2006**). Physical fitness may be conceived as the capacity to perform one's daily tasks without fatigue; motor fitness, also termed motor ability, refers to a person's performance abilities as affected by the factors of speed, agility, balance, coordination, and power **(Gallahue, 2006).**

Motor quality development is classified into two types including fine and gross motor development. Fine motor development can be defined as development of precise movements that use the small muscles to control small movements of the hands, wrists, fingers, feet, toes, lips, and tongue **(Payne & Isaacs, 2005; Gallahue & Ozmun, 1998**). Gross motor development can be defined as development of movements that use the large muscles of the body **(Gallahue & Ozmun, 1998),** which enabling functions such as walking, kicking and throwing.

2.5.1. Relationship of childhood obesity with motor quality parameters

Poor motor quality have been linked with higher body mass index and body fat percent in childhood in a number of studies **(D'Hondtet et al., 2011; Lopes et al. 2012).** Overweight and obese children show poorer gross motor quality performance as well as worse fine motor precision and manual dexterity than their healthy weight peers (**D'Hondtet al., 2011**). Obese children and adolescents perform worse on tasks of visuospatial organization, global executive functioning, and tasks of executive function involving planning and mental flexibility **(Boeka & Lokken, 2008).**

A diversity of activities has been shown to improve executive functioning needed for motor planning **(Diamond & Lee, 2011),** however children who are overweight and obese engage in limited physical activity thereby increasing chances for poor motor planning. Impairments in these components of cognitive processing weaken the ability to plan movements leading to poor at 6 to 10 years predicted declines in gross motor coordination performance 2 years later **(D'Hondtet al. 2013).**

However, the reverse was not tested, that is, whether initial poor motor quality contribute to a subsequent unhealthy weight. Similarly, other studies have found that low levels of fitness and motor competence are strongly associated with the risk of subsequently becoming overweight or obese **(Kimet et al., 2005; Hruby et al. 2012; Rodrigues et al. 2016).** It is reasonably well established in literature that there is an inverse association between adiposity and motor skill, i.e., overweight and particularly obese children display markedly poorer performance and are less competent in motor tasks requiring support, propulsion, or movement of a great proportion of body mass compared with their normal weight counterparts **(Okely et al., 2004; D'Hondt et al., 2011; Lopes et al., 2012). Rivilis et al.** in **2011** concluded that an adverse body composition was associated with poor motor proficiency regardless of the measure of adiposity considered. Body size and weight are negatively correlated to motor fitness tests where the body is projected or work is performed against gravity (as running, jumping, sit-ups); though, the association between biological factors and motor quality or abilities in prepuberty was found to be relatively low in several studies **(Silva et al., 1984; Ball et al., 1992).**

In addition**, Morrison et al.** in **2012** reported that besides being significantly correlated with motor coordination scores when controlled for body fat, physical activity status influenced the relationships between body fat percentage and motor coordination scores in primary school children.

Another study assessed motor skills among obese young children, and reported that motor skills are adversely associated with childhood obesity. Skills most directly related to body weight and object controlling, jumping and hopping **(Castetbon & Andreyeva. 2012).** Over the last decade, sedentary behaviours have increased and the level of physical activity has decreased specially among obese children. Obese and overweight children present lack of physical activity and this is linked to insufficient motor experience and development of gross motor and fine motor skills **(Okely et al., 2004; Morrison et al.**, **2012).** Children who are obese or overweight are poorer in gross and fine motor control and have delayed motor development **(Slining et al., 2010; Gentier et al., 2013; Krombholz, 2013; Roberts et al., 2012; Poulsen et al., 2011)**. Obese boys have poorer motor skills and reduced activity of daily living. **Cliff et al.** in **2012** observed that the prevalence of mastery of all fundamental motor skills is lower in overweight or obese children, especially for run, slide, hop, dribble, and kick.

In addition, waist circumference is also related to children's and adolescents' ability to perform fundamental motor skills **(Okely et al., 2004)**. There is an inverse relationship of

BMI, waist circumference with fine motor precision, balance, running speed and agility, and strength in the 1st graders **(Kemp & Pienaar, 2013).** Obese children were found to also have difficulty in postural coordination and a heightened dependency on vision during locomotion which is rather automatic in nonobese children **(D'Hondt et al., 2011)**

Adiposity is related to muscle quality ratio that is associated with motor conduction velocity and finger tapping speed **(Moore et al., 2014).** Obesity is related to greater fluctuation in handgrip force production **(Mehta & Shortz, 2014).** Subcutaneous fatness can account for a significant variance of health-related and motor fitness **(Malina et al., 1995).** Excessive fat mass is associated with poorer posture and walking **(Ponta et al., 2014).**

In middle and older adults, a combination of high body mass index (or waist circumference) and high blood pressure is related to lower motor speed and manual dexterity **(Waldstein et al., 2006)**. During postural control, obese individuals require greater attention resources to maintain balance during unipedal stance **(Mignardo et al., 2010);** this implicates that obese people consume attention resources to compensate for their motor deficits.

On the other hand, a number of factors may mediate obesity's effects on cognition and motor behaviours. For instance, obesity may affect brain structure, leptin and insulin dysregulation, oxidative stress, cerebrovascular function, blood-brain barrier, and inflammation **(Smith et al., 2011; Nguyen et al., 2014; Arnoldussen et al., 2014; Gonzales et al., 2012; Frisardi et al., 2010).** Some also suggest that obesity related changes in metabolism interact with age to impair brain functions **(Keller et al., 2009).**

Obese individuals have lower cortical thickness in the left superior frontal and right medial orbitofrontal cortex. The volumes of ventral diencephalon and brain stem are also reduced in obese people **(Iturria et al., 2013).** There is also a negative relationship between neuronal injury and gray matter density in hippocampus and cerebellum in overweight and obese individuals **(Mueller et al., 2012)**. It is suggested that the medial orbitofrontal cortex, hippocampus, and cerebellum are involved in reward-based learning, memory, and motor control and learning **(Doya et al., 2000; Walton et al., 2010).** Structural alterations in these regions may be associated with deficits in cognitive and motor function.

So, obesity has become a worrying health and public issue. It affects motor quality mainly through degrading musculoskeletal system and cognition through altering the brain structures and functions **(Moore et al., 2014; Walther et al., 2010; Bolzenius et al., 2015).** A host of previous research has suggested that exercise can improve both obesity-related and motor and cognitive declines. As more and more people develop obesity in childhood, introducing exercise involvement early would result in the greatest benefits.

2.6. Relations of obesity with physiological parameters

2.6.1. Blood pressure

Blood presssure is a critical measure of the adequacy of the circulatory system. At a given moment it reflects the balance between the blood volume ejected from the left ventricle of the heart with each cardiac cycle and resistance to blood flow, which is controlled mainly by the distal vusculature. Blood pressure varies from moment to moment throughout each cardiac cycle, is altered rapidly by physical and physiological influences. Blood pressure too low is medical emergency and is part of the clinical syndrome of the circulatory shock. Blood pressure that is too high is cause of many pathological. High blood pressure is often related to progression of atherosclerosis as well as vuscular changes characteristics of hepertension alone **(Labarthe, 1998; Bibbins et al., 2007).**

Hypertension is the most common and potent universal contributor to cardiovascular mortality. Hypertension is increasingly common in overweight and obese children. In which condition, blood pressure is chronically elevated levels considered desirable or healthy for a person's age and size. High blood pressure causes the heart to work hardar than normal, as it has to expel blood from the left ventricle against a greater resistence. Elevated blood pressure, labile or fixed, systolic or diastolic, at any age, in either sex is a contributor to all forms of cardiovascular diseases **(Kannel, 1975; Bibbins et al., 2007).** Furthermore, hypertension places great strain on the systematic arteries and arterioles. Overtime these stresses can cause the heart to enlarge and arteries and arterioles to become scarred, hardened and less elastic. Eventually this can lead to atherosclerosis, heart attack, heart failure, stroke and kidney failure **(Wilmore & Costill, 1994).**

Hypertension in the pediatric patient is categorized into several types **(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004)**: Pre-hypertension - when the Systolic Blood Pressure (SBP) or Diastolic Blood Pressure (DBP) is between 90th and 95th percentile or greater than 120/80 mmHg, Stage 1 hypertension - when the SBP or DBP is between 95th and 99th percentile plus 5 mmHg, or if the BP exceeds 140/90 mmHg in adolescents even if the value is <95th percentile, Stage 2 hypertension - when the SBP is > 99th percentile plus 5 mmHg. If there is a disparity between the SBP and DBP, the higher percentile value of either of these determines the blood pressure category.

Association between obesity and hypertension in children has been reported in numerous studies among a variety of ethnic and racial groups, with virtually all studies finding higher blood pressures and/or higher prevalences of hypertension in obese compared with normal weight children **(Elcarte et al., 1993; Verma et al., 1994; Guillaume et al., 1996;**

Macedo et al., Freedman et al., 1999; Morrison et al., 1999; Sorof et al., 2002; Mohan et al., 2004; Khadilkar et al., 2004; Ferreira et al., 2015).

The most comprehensive study by **Rosner et al. (2000)** pooled data from 8 large US epidemiological studies involving over 47000 children to describe the blood pressure differences between black and white children in relation to body size. Irrespective of race, gender, or age, the risk of elevated blood pressure was significantly higher for children in the upper compared with the lower decile of BMI, with an odds ratio of systolic hypertension ranging from 2.5 to 3.7. **Freedman et al. (1999)** reported that overweight children in the Bogalusa Heart Study were 4.5 and 2.4 times as likely to have elevated systolic blood pressure and diastolic blood pressure, respectively. Moreover, **Sorof et al. (2002)** reported a 3 times greater prevalence of hypertension in obese compared with nonobese adolescents in a school-based hypertension and obesity screening study.

The majority of data on the pathophysiology of obesity hypertension are derived from studies of animals, and in heart rate and in blood pressure associated with decreased parasympathetic heart rate control **(Sorof & Daniels, 2002).** Physical exercise or training in obese children appears to alter autonomic function by reducing the ratio of sympathetic to parasympathetic activity **(Gutin et al., 1997).** These study suggest that autonomic function has an important mediating role in the pathogenesis of obesity hypertension in children and also in adults. Increased blood pressure variability could be a manifestation of increased sympathetic activity as well. Obese children with isolated systolic hypertension had a higher resting heart rate and higher blood pressure variability, suggesting a role for sympathetic nervous system hyperactivity in the development of hypertension in obesity **(Sorof et al., 2002).**

A study performed in a group of obese children and adolescents aged 7–18 years confirmed the association of sympathetic nervous system activity with blood pressure. Elevated systolic blood pressure was associated with higher urinary noradrenaline levels, suggesting hyperactivity of the sympathetic nervous system **(Gilardini et al., 2008).** Baroreflex is a known regulatory mechanism engaged in blood pressure control, providing a quick feedback loop to decrease or increase blood pressure through heart rate regulation, mediated by both sympathetic and parasympathetic nerves. In a group of normal and overweight adolescents, a decreased baroreflex sensitivity was associated with hypertension **(Krontoradova et al., 2008).**

In addition, Insulin resistance has been implicated in the pathogenesis of obesity related hypertension in children **(Sorof & Daniels, 2002).** Several studies have reported positive associations between fasting insulin levels and resting blood pressure in obese children **(Young et al., 2001; Lughetti et al., 2001; Lughetti et al., 2000; Ciba at al., 2015; Heianza et al., 2011).**

Lughetti et al. (2000) studied 350 obese children who were categorized as hypertensive or normotensive. Although insulin was significantly higher in hypertensiveh and in normotensive children, the difference was not clinically relevant. Furthermore, insulin explained only a small amount of systolic and diastolic blood pressure variance, which disappeared after accounting for the confounding effects of age, weight, or other anthropometric dimensions. **Csabi et al. (1996)** found no relationship between insulin levels and reduced sodium excretion in obese children. Thus, a causal role of insulin resistance in the pathogenesis of obesity hypertension remains uncertain. Altered vascular structure and function may also contribute to the pathogenesis of obesity hypertension. Ultrasound of the carotid artery has demonstrated increased intimal-medial thickness in diabetic children and children with familial hypercholesterolemia, compared with normal controls **(Jarvisalo et al., 2002; Jarvisalo et al., 2001).**

On the other hand, coronary artery disese is one of the leading causes of death and disability. Obesity in children has been associated with the development of early myocardial changes and coronary and carotid artery pathology. An important current trend that may increase the future burden of coronary heart disease (CHD) is a significant increase in the prevalence of childhood obesity **(Daniels et al., 2005).** In obesity, many of the risk factors for CHD are clustered together. Moreover, these risk factors usually persist or track into adulthood, so that their effect on the cardiovascular system may be present and influential for several decades. Kortelainen evaluated the autopsies of 210 children aged 5 to 15 years who had suffered a violent death **(Kortelainen et al., 1997).**

Ponderal index was a significant predictor of heart weight and the presence of coronary artery intimal fatty streaks **(Celermajer & Ayer, 2006).** Similarly, **Berenson et al**. **(1998),** demonstrated in the Bogalusa Heart Study that children and young adults who died primarily of trauma showed an association between BMI, systolic blood pressure, diastolic blood pressure, and the presence of fatty streaks and fibrous plaques in the aorta and coronary arteries at autopsy.

Gidding et al. **(1998),** studied by electron beam computed tomography in 29 patients aged 11 to 23 years with familial hypercholesterolemia to evaluate the presence of coronary artery calcium. Coronary artery calcium deposits were found in 7 of 29 subjects and were associated with increased body mass index. **Sorof et al**. **(2002)** measured carotid intimal-medial thickness by duplex vascular ultrasound in children and adolescents with essential hypertension to assess for evidence of early arterial changes. Although raised diastolic pressure and systolic pressure are well risk factors for development of coronary artery disease and stroke in middle aged person, it is still not clear how diastolic and diastolic blood pressure levels are associated with coronary heart disease in children. As blood pressure is positively correlated with BMI in children, the prevalence of hypertension in childhood is likely to rise.

Paradis et al. **(2004),** have reported a high normal or elevated blood pressure in 30% of boys and 17% of girls 16 years aged. Weight loss and improved cardiovascular conditioning would thus be expected to lower blood pressure in children, although the evidence for this is limited. The increased carotid intimal-medial thickness and left ventricular hypertrophy observed in children and adolescents with essential hypertension are also correlated with BMI (**Paradis et al., 2004).**

So, high blood pressure places great strain on the systematic arteries and arterioles. Over time this stress can cause the heart to enlarge and arteries and arteroles to become scareed, hardnded and less elastic. Eventualy this can lead to atherosclerosis, heart attack, stroke and kidney failure.

2.6.2. Heart rate

Heart rate is an easy to measure but important indicator of cardiovascular health. Among the various cardiovascular risk factors, elevated resting heart rate is considered a risk factor which is independent of other factors such as obesity, hypertension, a sedentary lifestyle, and insufficient physical activity.

An elevated resting heart rate has been associated with adverse cardiovascular outcomes. Recent studies have identified that a higher resting heart rate is associated with elevated blood pressure, independent of body fatness, age and ethnicity. A high amount of body fatness is responsible for releasing a great amount of inflammatory adipokines into the blood stream which has an important role in the pathogenesis of many chronic diseases **(Huang, 2009; Kotsis et al., 2010).**

There is evidence that elevated resting heart rate (>80–85 beats/min) is directly associated with risk of developing hypertension, atherosclerosis and plaque disruption leading to various cardiovascular events **(Palatini, 2009)**. Increased resting heart rate is considered as an independent risk factor and a prognostic factor for cardiovascular and non-cardiovascular related diseases (**Seccareccia et al., 2001; Hall & Palmer, 2008).**

In adults, the use of resting heart rate as screening index for cardiovascular risk has been postulated **(Palatini et al., 2006)** and supported by studies that reported its relationship to mortality, independent of abdominal obesity **(Oda et al., 2009; Cooney et al., 2010).** Resting heart rate is regulated by parasympathetic and sympathetic nervous system. Thus, quantifying RHR can give an index of the load imposed on the heart and the state of imbalance between sympathetic and parasympathetic activity (**Hall & Palmer, 2008)**.

The autonomic dysfunction related with obesity could lead to changes not only in resting heart rate and blood pressure; it could also vary the responses to changes in posture **(Rabbia et al., 2002)**. **Fernandes et al. (2013),** in a study involving 971 adolescents aged 11 to 17 years, found that high resting heart rate was associated with dyslipidemia and elevated levels of glucose in this population. Epidemiological studies also indicate that elevated heart rate at rest is related to high blood pressure in children and adolescents **(Fernandes et al., 2011; Furusawa et al., 2005).**

2.6.3. Respiratory rate

Obesity affects both resting and exercise-related respiratory physiology. Severe obesity classically produces a restrictive ventilatory abnormality, characterized by reduced expiratory reserve volume. Sometime, obstructive ventilatory abnormality may also be related with abdominal obesity **(Sood, 2009).** On the other hand, obesity affects various resting respiratory physiological parameters such as compliance, neuromuscular strength, work of breathing, lung volumes, spirometric measures, respiratory resistance, diffusing capacity, gas exchange, and airway responsiveness to methacholine **(Sood, 2009).** Total respiratory compliance may be reduced in severe obesity with obesity-hypoventilation syndrome to as little as one-third of the normal. In other words, there may be up to a three-fold increase in elastic resistance to respiratory distension in severely obese individuals. This largely results from reduced distensibility of extrapulmonary structures from excess truncal fat. However, increased pulmonary blood volume and increased closure of dependent airways also contribute to the low lung compliance seen in severely obese subjects **(Rochester & Enson, 1974).** These physiological changes are more pronounced during recumbency in obese subjects, as compared to normal weight subjects, due to the increased gravitational effects of the large abdomen **(Koenig, 2001).**

Obese individuals may demonstrate inefficiency of respiratory muscles, particularly the diaphragm. Reduced respiratory muscle strength and endurance, as suggested by static maximal inspiratory pressure values of 60-70% of normal subjects, have been described among three severely obese subjects with obesity-hypoventilation syndrome in a 1974 study by **Rochester and Enson**. Different studies have confirmed that obese subjects are at greater risk for inspiratory muscle fatigue both at rest and with exercise **(Chlif et al., 2007; Chlif et al., 2006**). Furthermore, weight loss in severely obese subjects is associated with improved respiratory muscle strength and endurance **(Weiner et al., 1998).** A possible cause of impaired respiratory muscle function in obesity includes increased elastic load which the respiratory muscles are required to overcome during inspiration **(Weiner et al., 1998).** An overstretched diaphragm would place this respiratory muscle at a mechanical disadvantage, leading to decreased inspiratory muscle strength and efficiency **(Sharp et al., 1986).**

To overcome the reduced total respiratory compliance and respiratory muscle inefficiency, obese subjects may breathe rapidly and shallowly **(Chlif et al., 2006; Rochester, 1998).** This pattern of breathing is however associated with increased oxygen cost of breathing **(Kress et al., 1999).** The oxygen cost of breathing represents the oxygen consumed by the respiratory muscles per liter of ventilation and is an index of the energy required to breathe. Rochester showed that the oxygen cost of breathing is four-fold and ten-fold higher than normal among subjects with simple eucapnic obesity and obesity-hypoventilation syndrome respectively **(Kress et al., 1999).**

In addition, the most common and consistent indicator of obesity is a reduction in expiratory reserve volume **(Sutherland et al., 2008).** This occurs because of displacement of the diaphragm into the thorax by the obese abdomen and increased chest wall mass. Although this association is seen even with modest obesity, expiratory reserve volume decreases rapidly in an exponential relationship with increase in body mass index **(Jenkins & Moxham, 1991).** On the other hand, obesity has fairly modest effects on the extremes of lung volumes at residual volume and total lung capacity but a relatively larger effect in reducing functional residual capacity **(Jones & Nzekwu, 2006).**

An increase in airway resistance (as measured by body plethysmography) is reported in obese subjects (**Rubinstein et al., 1990; Zerah & Harf, 1990**). However, this may be attributable to breathing at low functional residual capacity which in turn results in a relatively decreased airway caliber throughout the tidal breathing cycle. This conclusion is supported by normal values of specific airway conductance **(Watson & Pride, 2005).** In obese subjects breathing at low lung volumes, the airways remain at smaller caliber and the airway smooth muscle is at shorter length throughout the breathing cycle **(Shore & Johnston, 2006).** It is possible that this would change the contractile properties of the airway smooth muscle, either by plastic adaptation to a shorter length or alterations in actin-myosin cross-bridge cycling , resulting in an increase in airway smooth muscle contractility and an increase in airway responsiveness **(Seow, 2005; Shore et al., 2006) .**

On the other hand, obesity is associated with increased rates of basal metabolism and oxygen consumption at rest **(Sood, 2009)**. However, since adipose tissue has a lower metabolic rate than other tissues, if VO_2 is standardized by expressing it per kilogram actual body weight, lower than normal values are obtained in obese individuals **(DeLorey et al., 2005).**

2.6.4. Cardio-respiratory fitness

Cardiorespiratory fitness, also called cardiovascular fitness or maximal aerobic power, is the overall capacity of the cardiovascular and respiratory systems and the ability to carry out prolonged strenuous exercise **(Ortega et al., 2008).** The maximal oxygen consumption (VO_2max) attained during a graded maximal exercise to voluntary exhaustion has long since been considered by the World Health Organization as the single best indicator of cardiorespiratory fitness **(Ortega et al., 2007).**

There is evidence that cardiorespiratory fitness and physical activity significantly reduce cardiovascular risks in adults. Epidemiological research has demonstrated that obesity and poor cardiorespiratory fitness performance contribute significantly to the prevalence of cardiovascular disease **(Froberg et al., 2005).** Results from the AVENA study groups indicate that high levels of cardiorespiratory fitness are associated with a more favourable metabolic profile (computed from age- and sex-specific standardized values of triglycerides, low density lipoprotein cholesterol, high density lipoprotein cholesterol and fasting blood glucose) in both overweight and non-overweight Spanish adolescents **(Mesa et al., 2006; Padilla et al., 2012; Perez et al., 2008)**. There are reasons to believe that there might be potential interactions between cardiorespiratory fitness and fatness in relation to cardiovascular risk **(Rizzo et al., 2007; Ekelund et al., 2007).**

Data from the Swedish part of the European Youth Heart Study, a school based cross-sectional study of risk factors for future cardiovascular disease in a random sample of children and of adolescents indicate that those individuals having a high cardiorespiratory fitness level also have significantly lower total adiposity, as measured by skinfold thickness **(Poortvliet et al., 2003).** When total fatness was assessed by a reference method, that is, Dual Energy X-ray Absorptiometry, a similar inverse association was found in Spanish 24 and North American children **(Lee & Arslanian, 2007).**

Cardiorespiratory fitness has shown a stronger association with total adiposity, as measured by skinfold thickness, than other physical fitness components such as muscular fitness, speed/agility, flexibility or motor coordination **(Art al., 2007).** Even in overweight or obese children, those children who had a higher cardiorespiratory fitness have shown a lower overall adiposity. Longitudinal data have shown a significant relationship between adolescent cardiorespiratory fitness and later body fatness **(Nassis et al., 2005).**

2.7. Changes in physiological parameters with age

Blood pressure is a physiological parameter that when elevated becomes a risk factor for the development of premature cardiovascular morbidity **(Tümer et al., 1999).** High blood pressure in early life is a major cause for heart disease and stroke in later life. There is enough evidence to suggest that the roots of essential hypertension in adults extend into childhood. Blood pressure variation depends upon age, sex, and body maturation and it also varies between populations according to ethnic and environmental factors **(Menghetti**

et al., 1999; Sharma et al., 1999; Merhi et al., 2011). The rise of blood pressure with the increase in age is most probably caused by the growth of the child (**Merhi et al., 2011)**. Body composition rather than the chronological age must be taken into consideration in assessing blood pressure in children. Many epidemiological studies in children have shown a strong correlation between blood pressure, height, and weight **(Tazeen et al., 2005).**

On the other hand, resting heart rate and respiratory rate are key vital signs used to assess the physiological status of children in many clinical settings **(Fleming et al., 2011**). In 1992, **Hooker et al.** presented a series of 434 children attending to an emergency department, concluding that respiratory rate was inversely proportional to age. Resting pulse rate is inversely associated with age and resting pulse rate gradually decline between infancy and early childhood, as well as the more gradual decline to lower pulse rate (which are more typical for adults) around age **(Ostchega et al., 2011).**

2.8. Coronary artery disease

Coronary artery disease (CAD) is caused by atherosclerosis of the coronary arteries that leads to a restriction of blood flow to the heart. Coronary artery disease (CAD) is also called coronary heart disease (CHD) and ischemic heart disease (IHD) **(Labarthe, 1998**). Atherosclerosis is a process that develops slowly over time. Typically, atherosclerosis begins in a person’s teenage years or earlier, and the disease worsens quietly for decades. Throughout the world coronary artery disease causes more deaths and disabilities and is responsible for more economic costs than any other single illness **(WHO, 2015).** The current epidemic of childhood obesity has been projected to further increase rates of coronary artery disease in young and middle-aged adults, and it is estimated that the prevalence of coronary artery disease may increase by 5–16% by the year 2035 **(Bibbins et al., 2007).**

Among the clinical expression of coronary artery diseases congestive heart failure, conduction defect, arrhythmia, angina pectoris and myocardial infarction (heart attack). Most cases sudden unexpected death also results from coronary artery disease. Before clinical symptoms have been evolved the diagnosis of coronary heart disease is difficult because coronary sclerosis may be masked by the coronary reserve.

Atherosclerosis is the disorder that underlies coronary artery disease. Atherosclerosis thickens the walls of medium and large arteries. The atherosclerotic thickenings occur as bulges called plaques in the arterial walls. Plaques contain lipids, white cells, smooth muscle cells, and connective tissue in a poorly organized mass that lies just under the endothelial lining of the artery wall. When atherosclerosis causes the coronary arteries to become very narrow or when plaques rupture and send clots into the arteries of the heart, a person is said to have coronary artery disease **(Wilmore & Costill, 1994).** The heart muscle is constantly active, and it requires a continuous blood supply. When a heart artery is blocked suddenly, the heart muscle it supplies stops working within a few minutes. If the blood supply remains blocked for a half hour or more, the heart's muscle cells will begin to die.

Atherosclerosis is not disease of the aged. Rather, it is more approximately classified as a paediatric disease because the pathological changes that lead to atherosclerosis at infancy and progress in childhood **(Kannel & Dawber, 1972).** Fatty streak or lipid deposits that are thought to be precursors of atherosclerosis starts from age 3 to 5. These fatty streak starts to appear in the coronary artery in the early teen can develop into fibrous plaques during the 20s, and can progress to complicated lesion during the 40s and 50s.

Most atherosclerosis causes no clinical problems. Many people have atherosclerosis throughout their bodies but develop no serious medical symptoms, and the disease is only discovered at autopsy **(Lam, 2012).** Coronary artery disease is a chronic disease that is punctuated by sudden medical emergencies, the acute coronary syndromes. Complete, sudden blockage of an artery is not the only problem. Even a reduced blood supply will reduce the oxygen supply to heart muscle, and an oxygen-starved heart muscle responds with a characteristic feeling of pain or discomfort called angina. When its arteries are narrowed by atherosclerosis, a heart may still get enough oxygen to pump blood at rest. On the other hand, exercise increases the work of the heart, and narrowed arteries cannot always deliver the excess oxygen required by an exercising heart. Under these circumstances, a person with narrowed coronary arteries will develop angina when exercising. One of the first symptoms of coronary artery disease is the appearance of angina when a person is working strenuously.

The long, chronic phases of the disease have two forms these are stable angina and stable ischemic heart disease **(Schoen, 2010).** When one or more coronary arteries have become narrowed and cannot meet the demands of a hard-working heart, the patient has chronic stable angina. This syndrome is characterized by ischemic heart pain that shows up when patients exercise and that goes away in a few minutes after they rest. Blood flow to the heart must be reduced by two thirds to three fourths before a patient develops the symptoms of chronic stable angina. This syndrome is characterized by ischemic heart pain that shows up when patients exercise and that goes away in a few minutes after they rest. Blood flow to the heart must be reduced by two thirds to three fourths before a patient develops the symptoms of chronic stable angina. The chest pain of chronic stable angina is short-lived and occurs predictably.

The occurrence of angina is influenced by the general tone of the sympathetic nervous system (which tends to be, for example, higher in the mornings) and by the demands of blood flow by the gastrointestinal tract after a meal. Therefore, although the symptoms of chronic stable angina are fairly predictable, the amount of exercise or stress that will produce these symptoms varies during the course of a day. The chest pain of chronic stable angina can also be brought on by any medical condition that increases the work of the heart, such as hypertension, aortic stenosis, systemic infections, or thyrotoxicosis. Likewise, conditions that reduce the oxygenation of the blood, such as anaemia, or high altitudes, can also cause angina.

On the other hand, a second chronic syndrome is stable ischemic heart disease, or ischemic cardiomyopathy, in which years of damage from ischemia have weakened the heart sufficiently that it gradually, fails. Stable ischemic heart disease is a major cause of congestive heart failure in older adults. Most patients with this condition have had acute myocardial infarctions in the past, although not all infarctions may have been symptomatic. In people who have had “silent” myocardial infarctions, heart failure from stable ischemic heart disease can be the first evidence of their coronary artery disease **(Graham et al., 2011).**

Myocardial infarctions are a type of acute coronary syndrome. Most myocardial infarctions are caused by clots dislodged from atherosclerotic plaque with or without vasospasms (i.e., sudden, temporary contractions of the muscles inside the walls of a coronary artery). Myocardial infarctions occur when a chunk of plaque, a blood clot, a vasospasm, or some combination of these completely obstructs a coronary artery or one of its major branches. If the obstruction persists for more than about 30 minutes, some of the cell injury will be permanent. The area of the heart damaged by a myocardial infarction is called a myocardial infarct. A myocardial infarction produces distinctive ECG changes. In addition, the cell necrosis in the infarct allows intracellular muscle molecules to leak into the bloodstream, and these heart molecules can be detected in blood tests **(Falk & Fuster, 2011).**

Obese children may have several coexisting risk factors that are detrimental to cardiovascular health. Although the clinical effects of these cardiac risks may not be notable in childhood, their existence and persistence into adulthood are of concern. The commonly noted conditions that promote cardiovascular comorbidities in obese children include dyslipidemia, which is manifest as high triglycerides, and usually a combination of high total and LDL cholesterol, low HDL cholesterol, and high VLDL cholesterol concentrations.

There is a strong association between childhood obesity and early-onset dyslipidemia, hypertension, and insulin resistance. These conditions, when manifested in childhood, track into and worsen in adult life because obese children are more likely to become obese adults **(Serdula et al., 1993; Whitaker et al., 1997).** Childhood-onset obesity itself and its associated comorbidities have an adverse effect on the vasculature, which results in premature onset and accelerated progression of atherosclerosis **(Freedman et al., 2008; Berenson et al., 1998**). Childhood obesity itself and its associated co-morbidities have an adverse effect on the vasculature, which results in premature onset and accelerated progression of atherosclerosis (**Freedman et al., 2008)**. This could result in much higher rates of hospitalizations, interventions, disabilities, and premature deaths in the coming decades as the current cohort of obese children ages **(Di'Pietro et al., 1994; Mossberg, 1989)**

Pediatric epidemiologic studies have shown that high total cholesterol (TC), high body mass index (BMI), high low density lipoprotein cholesterol (LDLC), low high density lipoprotein cholesterol (HDLC) in childhood are associated with an increased carotid artery intima-media thickness, a marker of atherosclerosis and heart disease, in adulthood **(Davis et al., 2001; Raitakari et al., 2003)** . The Bogalusa Study, which involved a long-term follow-up of a racially diverse population sample, showed that the atherosclerotic lesions in the coronary arteries were increased in youth with multiple atherosclerosis-promoting risk factors (**Berenson et al., 1998**. These investigators also showed that childhood obesity that tracked into obesity in adult life resulted in a further increase in carotid artery intima-media thickness, which suggests that the adverse vascular effects of childhood-onset obesity persist (**Freedman et al., 2008).**

Historical and autopsy data have attested to the childhood origins of this disease and its long, presymptomatic, "silent" period. Among young, apparently healthy, victims of the Korean and Vietnam wars who were autopsied, there was a 45–77% prevalence of atherosclerosis of the coronary arteries, which suggested its childhood origins **(Enos et al., 1953; McNamara et al., 1971).** These observations were made 50> years ago when the prevalence of childhood obesity was lower than it is at present. In the 1990s, investigators from the Pathobiological Determinants of Atherosclerosis in Youth research group reported the link between atherosclerosis and risk factors such as dyslipidemia, stress, tobacco smoke exposure, hypertension, diabetes, and age, and in a follow-up study suggested a link between abdominal obesity and coronary artery lesions in youth **Anonymous, 1990** ; **McGil et al., 2002)**. These risk factors attributed with a causal relation to atherosclerosis. For some time each risk factor was looked at separately. However, it soon became evident that these risk factors are not simply additive. A second, less significant risk factors category includes diabetes mellitus, gout, adiposity and physical inactivity and stress.

2.8.1. Risk factors associated with coronary artery disease

Cardiovascular complications of excess weight in children include dyslipidemia, hypertension and insulin resistance. In adults, there is emerging evidence that obesity itself may be an independent risk factor, although the evidence directly linking obesity as an independent risk factor to coronary heart disease in children is not yet as strong **(Zalesin et al., 2008).** Long standing risk factors for the development of coronary artery diseses (CAD) have typically include age, obesity, blood levels of total or high density lipoprotein cholesterol (HDL), triglycerides, blood pressure, diabetes mellitus, and left ventricular hypertrophy on echocardiograph **(Zhang et al., 2006; Gaziano et al., 2006).**

2.8.1.1. Obesity and abdominal adiposity

Anthropometric obesity markers such as body mass index (BMI), body fat percent, waist to hip ratio (WHR), and waist to thigh ratio (WHR), waist to height ratio (WHtR), waist circumference (WC), mid upper arm circumference (MUAC) have been associated with the risk of coronary artery disease (CAD).

Adiposity (overweight and obesity) is a potent risk factor for development cardiovascular disease (CVD) and is familiar in recent obesity screening and treatment guidelines for both adults and children **(Grundy et al., 2004; Adams et al., 2006; Daniels et al., 2008; Kavey et al., 2006).**

Adipocytes secrete fatty acids, express renin-angiotensin system components (e.g. angiotensin converting enzyme), and release inflammatory factors which advance atherosclerosis by respectively promoting insulin resistance and hyperlipidemia, high blood pressure, and vascular inflammation **(Tchern et al., 2013)**. In particular, visceral adipocytes are extremely metabolically active, and are powerful sources of these compounds - especially inflammatory factors, which are recognized as both risk factors and common pathologic features of coronary artery disease (CAD) **(Ridker & Silvertown, 2008).**

Measures of abdominal adiposity such as waist circumference (WC) or waist to hip ratio (WHR) indirectly assess visceral adipose tissue, and are associated with an increased risk of cardiovascular events **(de'Koning et al., 2007).** Despite their sometimes high correlation with BMI, using them with along with body mass index (BMI) often improves the predictive power of models **(Flint et al., 2010; Cerhan et al., 2014).** The importance of abdominal obesity assessment was recognized in 2008 by the College of Family Physicians of Canada, which endorsed the routine measurement of waist circumference (WC) or waist to hip ratio (WHR) in adults (**Iglar et al., 2008).** In children, association of waist circumference or waist to hip ratio with cardiometabolic risk assessment is unknown.

The major aspects of obesity relevant to health are fatness (i.e., tissue composition of the body), overweight (relative to either reference standards or individual height) and central or abdominal adiposity (i.e., fat distribution with a relative excess abdominal girth). Central adiposity refers to the anatomical distribution of body fat. On the other hand, intra-abdominal or visceral adipose tissue is important in this regard which includes omental, mesenteric, and retroperitoneal fat that differ in metabolic characteristics from peripheral stores **(Bojrntrop, 1992).** Roughly equivalent terms to concentration of fat in this region are central adiposity, visceral obesity, abdominal or truncal obesity. Obesity, in its various manifestations, contributes to the occurrence of cardiovascular disuses (CVD) and other risk factors.

An extensive body of evidence demonstrates a harmful effect of excess adiposity and obesity on cardiovascular health. Both abdominal obesity and general obesity are independently associated with coronary artery disease (CAD) and others cardiovascular diseases (**Hu et al., 2007; Strazzullo et al., 2010; Kurth et al., 2005; Nelson et al., 2002; Gruson et al., 2010) .**

Furthermore, obesity is associated with increased overall mortality and mortality after cardiovascular events **(Pischon et al., 2008; Whitlock et al., 2009; Towfighi et al., 2009).** Although some studies have shown a J-shaped curve between BMI and mortality, with higher mortality rates in individuals in both the highest and lowest BMI categories, often referred to as the "obesity paradox," co-morbidities associated with excess adiposity appear to increase across the continuum of overweight and obesity **(Oki et al., 2006).**

On the other hand, abdominal obesity, an important component of the metabolic or the cardiometabolic syndrome, has been shown to be associated with stroke, coronary heart disease, and overall mortality independent of other cardiac risk **factors (Chen et al., 2006; Cabrera et al., 2007; Jacobs et al., 2010)**

The numerous of longitudinal studies determining changes in adiposity over time rely on the use of body mass index (BMI) or body weight. Reductions in body weight and BMI have been established to improve risk factors for cardio vascular disease (CVD), including type 2 diabetes mellitus (T2DM) and hypertension **(Hamman et al., 2006; Appel et al., Adeghate et al., 2006; Delli et al., 2010).**

Despite of improvements in morbidity, reductions in body weight have not clearly demonstrated improvements in mortality. In fact, in several prospective studies, weight loss is associated with increased all-cause mortality. One concern in using weight loss or body mass index (BMI) change as a measure in predicting outcomes is that these measures do not differentiate between loss of fat mass and lean body mass.

Although ideally, weight loss should result in loss of fat mass, there is also loss of fat-free mass, and the percentage of weight lost as fat-free mass has been found to be different even among similar weight loss ranges **(Allison et al., 1999).** Rapid weight loss, for example, may cause significant lean mass loss whereas people engaged in intense exercise programs might gain weight at the expense of increased muscle mass without any increase in fat mass. Decreases in fat mass or lean mass may be better predictors of outcome than weight and body mass index (BMI)**.**

In an analysis of prospective population cohorts, weight loss was associated with increased mortality, whereas loss of fat (measured by skinfold thickness) was associated with decreased mortality (**Allison et al., 1999).** Comparisons of measures of adiposity suggested that although BMI and fat mass are both predictive of mortality, waist to hip ratio (WHR) were stronger predictors **(Ogden et al., 2010).**

Moreover, waist circumference (WC) and waist hip ratio (WHR) increasingly have become therapeutic goals in weight loss trials or dietary interventions or, supported by the strong epidemiological evidence linking measures of adiposity with metabolic syndrome, cardiovascular events, and onset of type 2 diabetes mellitus (T2DM). Visceral fat mass seems to be linked to the development of coronary artery disease (CAD) and non-insulin dependent diabetes and to established metabolic risk for development for increased blood lipids as well hypertension (**Ogden et al., 2010; Cerhan et al., 2014; Bojrntrop, 1992).**

On the other hand, waist to thigh ratio (WTR) has also been seen shown to be independent risk factors for coronary artery disease, non insulin dependent diabetes mellitus than dose waist to hip ratio WHR **(Cigolini et al., 1990; Keum et al., 2013).** In a paediatric population at high-risk for developing cardiovascular disease, both overall and abdominal adiposity as measured by body mass index (BMI) and waist circumference (WC) or waist to hip ratio (WHR) are associated with an adverse pattern of blood lipid markers including high TG, high LDLC (low density lipoprotein cholesterol), and low HDL cholesterol.

Anthropometric assessment of cardiovascular disease risk is now routine clinical practice, mainly because adiposity is a major risk factor for conditions that lead to coronary heart disease (CHD) including abnormal blood lipids, elevated fasting blood glucose, hypertension, hyperuricemia, and type 2 diabetes **(Tchern & Despres, 2013**). Increasing attention is now being paid to abdominal adiposity, characterized by an increased waist circumference (WC) or waist to hip ratio (WHR), because it provides information about risk for Coronary heart disease (CAD) above and beyond that provided by body mass index (BMI) **(Yusuf et al. 2006).**

So, obesity represents several distinct concepts pertaining to body composition, relative body weight, and body fat distributions. The studies of determinants of obesity and of potential mechanisms by which obesity could have adverse cardiovascular effects have provided extensive information but some time conflicts results. The general conclusion is that obesity and central obesity are related to high blood pressure, adverse lipid profile and insulin resistance, and may constitute a potential health hazard.

2.8.1.2. Blood lipids

Adverse blood lipid profile denotes the multiplicity of lipid substances in blood implicated in the pathogenesis of atherosclerosis and its manifestation. For many years cholesterol and triglycerides are only the lipids observed in these epidemiological studies but the role of lipids in the development of atherosclerosis was rather confusing. Lipids by themselves are insoluble in the blood and termed as lipoproteins. Three major lipoprotein classes, different in their particle sizes, chemical compositions and physiochemical properties present in the plasma or serum of the healthy fasting subjects and can be separated by ultracentrifugation. There are very low density lipoprotein cholesterol (VLDL), the low density lipoprotein cholesterol (LDL) and high density lipoprotein cholesterol (HDL).

Raised low-density lipoprotein cholesterol (LDLC) plasma concentration is a major risk factor for atherosclerotic cardiovascular disease. Moreover, a sharp rise in LDLC plasma concentration indicates high cardiovascular risk and needs earlier clinical care **(Merino et al., 2014)**. There is strong relationship between plasma levels of small dense low-density lipoprotein cholesterol and risk for incident coronary artery disease (CAD) (Hoogeveen, et al., 2014). Similarly, autosomal dominant hypercholesterolemia (ADH) is characterized by markedly elevated level of LDL cholesterol that leads to premature morbidity and mortality from atherosclerotic cardiovascular disease atherosclerotic cardiovascular disease Similarly, familial combined hyperlipidemia is characterized by variable elevations of total cholesterol, triglycerides, or LDL cholesterol and a high risk of premature atherosclerotic cardiovascular disease **(Greyshock et al., 2014)** There is strong relationship between plasma levels of small dense low-density lipoprotein cholesterol and risk for incident coronary heart disease (CHD) **(Hoogeveen et al., 2014).**

On the other hand, plasma levels of high-density lipoprotein cholesterol (HDLC) have an inverse relationship to the risks of atherosclerosis and cardiovascular disease (CVD). Both HDLC and its components also indicate emerging risks of cardiovascular diseases in relation to apolipoprotein level **(Shokrani et al., 2014).** Measurements of apolipoproteins B (ApoB), apolipoproteins A-I and lipid particle size also work as cumulative indicator and correlated with cardiovascular risks. In particular, the paraoxonase (PON) family of enzymes, which circulates predominantly on HDL particles, plays a role in the antioxidant and anti-inflammatory activities of HDL. Hence, low levels of paraoxonase activity are associated with elevated systemic levels of markers of oxidative stress and with a greater likelihood of clinical events. Overall examination of lipoproteins in patient's serum also elucidates cardio-metabolic risk stratification **(Shokrani et al., 2014).** Recently, the cholesterol efflux capacity from macrophages was also proven to be an excellent metric of HDL functionality. It has a strong inverse relationship with the risk of angiographically documented coronary artery disease, independent of the HDL and apolipoprotein A1 levels, although it may not actually predict the prospective risk for cardiovascular events. Thus, improving the quality of HDL may represent a better therapeutic target than simply raising the HDL level and assessment of HDL function may prove informative in refining our understanding of HDL-mediated atheroprotection **(Ramjee et al., 2011).** Thus, measurement of standard lipid profile, including total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides is recommended to form an integral component of approaches to cardiovascular risk prediction. Moreover, patients with established atherosclerotic disease are considered to be at high risk and should undergo intensive treatment and risk factor modification. Therefore, modification of high LDL and low level of high-density lipoprotein (HDL) in cardiovascular atheroprotection is highly needful **(Ram, 2013).**

More specifically, correlation between non-high-density lipoprotein and low-density lipoprotein cholesterol can be used as important markers **(Ram, 2013).** There is an inverse relationship between HDL levels and the risk for coronary artery disease, which is independent of the low-density lipoprotein levels. Similarly, both detection and treatment of atherogenic low-density lipoproteins **(Sniderman & Kwiterovich, 2013)** and non-high density lipoprotein cholesterol versus apolipoprotein B assist in cardiovascular risk stratification **(Ramjee et al., 2011**). For this reason, measuring blood lipid profiles total cholesterol and low-density lipoprotein cholesterol (LDLC) levels in the fasting state in blood plasma provides more accurate diagnosis. In addition, triglycerides, apolipoprotein B (ApoB), and non-high-density lipoproteincholesterol (non-HDLC) are also suitable parameters to assess cardiovascular risk and to guide lipid-lowering therapy (**Ramjee et al., 2011)**.

Most commonly, clinicians easily find an explanatory detective note by using lipid estimation in both the fasting and non-fasting states. In most cases, postprandial lipid profiles in combination with ApoB are as useful as fasting lipid profiles for the differentiation between familial lipid disorders, such as heterozygous familial hypercholesterolemia, familial combined hyperlipidemia, and familial hypertriglyceridemia **(de'Vries et al., 2014).** ATP-binding cassette transporter A1 (ABCA1) mediates cholesterol efflux to lipid-free apolipoprotein AI 'ApoAI' and Apolipoprotein E (ApoE). ATP binding cassette transporter A1 (ABCA1) is an essential regulator of high-density lipoproteins (HDL) and reverse cholesterol transport. It also acts as an important biomarker for atherosclerosis. ABCA1, via its control of ApoE lipidation, has a role in Alzheimer's disease (AD) and has impact on A deposition and clearance in AD model mice **(Koldamova, et al., 2014**). Moreover, knockdown of FKBP51 showed reduced lipid accumulation and expression of adipogenic genes. It acts as a key regulator of adipogenesis via the Akt/p38 pathway and as a potential target in the treatment of obesity and related disorders **(Stechschulte et al., 2014).**

On the other hand, a number of population studies have investigated whether plasma TG are an independent risk factor for coronary artery disease **(Stalenhoef et al., 2008; Hokanson et al., 1996; Abdel et al., 2008).** Presence of elevated concentrations of atherogenic triglycerides rich remnant lipoproteins is the principle abnormality responsible for this association (**Stalenhoef et al., 2008).**

Though, the evidence for triglycerides (TG) being an independent risk factor for coronary heart disease (CHD) remains to some extent controversial because data obtained in large clinical studies were not always equivocal. Moreover, in the case of positive findings, the effect sizes were very modest. A number of issues have been raised to explain these inconclusive results. Plasma triglycerides are a highly variable lipid component, as it reflects the daily consumption of dietary fat. Nowadays humans consume at least three consecutive meals per day. As a consequence, people are in a continuous post-prandial state which is reflected in highly variable plasma TG levels **(Mora et al., 2008).**

Secondly, patients with high triglycerides levels frequently exhibit additional risk factors, such as insulin resistance that may affect their susceptibility to atherosclerosis. Finally, elevated plasma triglycerides levels are strongly associated with low HDLC levels **(Ginsberg et al., 2008).** In prospective epidemiological studies it will thus be difficult to separate the contributions of high density lipoprotein cholesterol (HDLC) and triglycerides (TG) to atherosclerosis susceptibility. Based on these limitations, investigators have argued that maybe non-HDL-C would be a better marker to explain the whole spectrum of atherogenic lipoprotein particles including low density lipoprotein cholesterol (LDLC), small dense LDL and VLDL remnants. Indeed a recent post hoc analysis was performed using combined data of the 'Treating to New Targets' trial and the 'incremental decrease in end points through aggressive lipid lowering' ideal trial and it revealed that on treatment levels of non-HDL-C but also apoB were more closely associated with cardiovascular outcome than LDL-C or total cholesterol levels **(Kastelein et al., 2008).**

Hypercholesterolemia is a strong risk factor for coronary artery disease (CAD). The importance of high triglycerides and low HDL cholesterol in predicting the risk factor of coronary artery disease is less established. **Jeppesen & Madshad** in **1996** reviewed that high triglycerides and low HDL cholesterol are important risk factors for coronary artery disease and suggested that combined lipid profiles of triglyceride, HDL cholesterol and total cholesterol (TC) provide more information about risk of coronary artery disease than total cholesterol alone.

In children, who are overweight or obese are at an increased risk of having an abnormal lipid profile (i.e., high total cholesterol, high triglycerides, high LDL cholesterol, and low HDL cholesterol) especially if they have an increased body fat percentage or waist circumference **(Williams et al., 1992; Dietz et al., 1998; Morrison et al., 1999; Caprio et al., 1996)**. The lipid profile usually shows high triglyceride levels and low high-density lipoprotein cholesterol levels. Low-density lipoprotein cholesterol levels are usually normal, but there may be qualitative changes in the low-density lipoprotein particles so that they become smaller, more dense and more atherogenic (**Zalesin et al., 2008).**

Prospective longitudinal studies have shown the impact of childhood BMI on the adolescent cardiovascular risk profile. The Avon longitudinal study of 5235 children reported that, in girls, a 1 standard deviation (SD) increase over mean BMI during 9–12 years was associated with cardiovascular risk factors at age 15–16 years in fully adjusted models, with odds ratio of 1.23 for high systolic blood pressure (SBP) (≥130 mm Hg); 1.19 for high low-density lipoprotein cholesterol (LDL-C) (≥2.79 mmol/l); 1.43 for high triglycerides (≥1.7 mmol/l); 1.25 for low HDL-C (<1.03 mmol/l); and 1.45 for high levels of insulin (≥16.95 IU/l) **(Lawlor et al., 2010).** The corresponding values in boys were 1.24 for systolic blood pressure, 1.30 for LDL-C, 1.96 for triglycerides; 1.39 for HDL-C, and 1.84 for high insulin levels.

Obesity has a strong association with atherogenic dyslipidemia. In a large series of 26000 overweight children, concentrations of one or more of the lipids were abnormal in 32%: total cholesterol in 14.1%, LDL-C in 15.8%, HDL-C in 11.1%, and triglycerides in 14.3% of those in whom data were available **(I'Allemand et al, 2008).** In a series of 943 school-going adolescents, **Musso et al.** reported significant differences in the levels of triglycerides (73 mg/dl vs 90 mg/dl; P< 0.001) and HDL-C (52 mg/dl vs 47 mg/dl; P< 0.001) between nonoverweight and overweight groups **(Musso et al., 2011).**

Atherosclerosis is a process that is known to start as early as the first years of life. In a series of 204 autopsies done on young individuals aged 2–39 years, **Berenson et al**. **(1998)** reported that BMI, systolic and diastolic BP, and serum concentrations of total cholesterol, triglycerides, LDL-C, and HDL-C were strongly associated with the extent of lesions in the aorta and the coronary arteries. Subjects with 0, 1, 2, and 3 or 4 risk factors had, respectively, 19.1%, 30.3%, 37.9%, and 35.0% of the intimal surface covered with fatty streaks in the aorta.

The corresponding figures for the coronary arteries were 1.3%, 2.5%, 7.9%, and 11.0%, respectively, for fatty streaks and 0.6%, 0.7%, 2.4%, and 7.2%, respectively, for collagenous fibrous plaques **(Berenson et al., 1998).** Surrogate markers of atherosclerotic disease like aortic intima media thickness and carotid intima media thickness are indirect evidence of the progression of atherosclerotic disease. Both aortic intima media thickness and carotid intima media thickness are documented to be associated with cardiovascular risk factors **(Dawson et al., 2009)**.

In a series of 228 adolescents (ages 11–17) aortic intima media thickness was positively correlated with triglycerides, systolic BP, diastolic BP, BMI, and waist/hip ratio, after adjusting for age, gender, and height. In the same population, carotid intima media thickness was positively correlated with systolic BP, pulse pressure, heart rate, BMI, and waist to hip ratio **(Dawson et al., 2009).**

These findings (from autopsy as well as from surrogate markers) and their correlations expose the putative effect of obesity in early life on vascular structures like the aorta and the coronary arteries which are the principle targets' of atherosclerotic disease.

So, adverse blood lipid profile comprise the variation in absolute and relative blood concentration of several types of lipid molecules and protein molecules with which they associated with blood and body tissues. In respect to epidemiological research it is viewed that total cholesterol has been most widely studied in population. But there is now substantial evidence on distribution and predictive importance of other blood lipid as well. This evidence relating childhood obesity to worsening of cardiovascular health, both immediate and long term, is convincing. The contribution of this pathological state in early life to future cardiovascular morbidity and mortality is one of grave concern. A holistic, multipronged, approach in the early phase of life is needed to contain this epidemic. Neglecting this threat will compromise the future cardiovascular health of our population and result in a serious public health crisis.

2.8.1.3. Hypertension

Hypertension is high blood pressure. The relationship of childhood obesity with blood pressure has been examined by many studies in the past. High blood pressure (BP) (i.e., BP >95th percentile) was seen in 35.4% of overweight children in the European pediatric cohort **(I'Allemand et al., 2009).** Data from other study covering 25000 school children in the age-group of 5–16 years reported similar figures from India **(Raj, 2009).** First instance hypertension was seen in 10.10% of normal-weight (nonoverweight, nonobese) children, 17.34% of overweight children, and 18.32% of obese children in this study. The corresponding figures for systolic (first instance) hypertension were 5.38%, 12.31%, and 14.66%, respectively and for diastolic hypertension (first instance) 6.45%, 8.86%, and

8.90%, respectively **(Raj, 2009).** The rate of change in body mass index (BMI) appears to be more significant than the absolute level of BMI in influencing pediatric BP as evidenced by a recent cohort of 12129 children from India **(Raj, 2009).**

Probable mechanisms of obesity-related hypertension include insulin resistance, sodium retention, increased sympathetic nervous system activity, activation of the renin-angiotensin-aldosterone system, and altered vascular function **(Kotchen et al., 2010).** Sympathetic nervous system activity is increased in obesity, particularly sympathetic activity to the kidney and skeletal muscle **(Vaz et al., 1997; Alvarez et al., 2002; Davy, 2004).** The probable reasons for over activation of the sympathetic nervous system in obesity include hyperinsulinemia and/or insulin resistance; increase in leptin, adiponectin, or other adipokines; rennin-angiotensin system over activity; and lifestyle factors **(Kotchen et al., 2010).** Hypertension is also causally related to sleep apnea, possibly due to sympathetic overflow as a consequence of intermittent hypoxia **(Friedman et al., 2009).** Obesity-related hypertension is associated with renal sodium retention and impaired pressure natriuresis **(Hall, 2003).** Obese humans subjects with the metabolic syndrome tend to be relatively salt sensitive **(Chen et al., 2009).** Activation of the rennin-angiotensin system may also contribute to obesity-related hypertension **(Kotchen et al., 2010).** Several studies suggest that plasma renin activity and plasma angiotensin II concentrations are elevated in obesity **(Sharma, 2004; Engeli et al., 2005).** Vascular endothelial dysfunction is associated with a number of cardiovascular risk factors, including obesity, insulin resistance, and hypertension **(Mark et al., 2009).** Increased sympathetic overactivity is a probable mechanism by which leptin may increase arterial pressure **(Kotchen et al., 2010).** Leptin activates the sympathetic nervous system both by centrally mediated effects on the hypothalamus and by local peripheral actions **(Mark et al., 2009).** Circulating adiponectin levels are decreased in obesity-induced insulin resistance, and some studies suggest that adiponectin is protective against hypertension through an endothelial-dependent mechanism **(Rasouli et al., Yiannikouris et al., 2010).** Whether hypertension is causally related to insulin resistance and/or hyperinsulinemia is a matter of debate. The probable reasons by which insulin resistance and/or hyperinsulinemia may increase blood pressure include an antinatriuretic effect of insulin, increased sympathetic nervous system activity, augmented responses to endogenous vasoconstrictors, altered vascular membrane cation transport, impaired endothelium-dependent vasodilatation, and stimulation of vascular smooth muscle growth by insulin **(Kotchen et al., 2010).** The putative role of insulin resistance in childhood obesity assumes significance in view of the fact that Indian children exhibit higher blood pressure in comparison to their Western (US) counterparts **(Raj et al., 2010). Luscher et al**. in **1996** have correlation between stroke, myocardial infarction and hypertension as well proven efficiency of hypertensive therapy in preventing cardiovascular events underscores importance of effective and sustained blood pressure control in patients.

So, high blood pressure places great strain on the systematic arteries and arterioles. Over time this stress can cause the heart to enlarge and arteries and arterioles to become scarred, hardened and less elastic. Eventually this can lead to atherosclerosis, heart attack, heart failure. Thus it is evident that obesity in children is a risk factor for later coronary diseases. In order to prevent or decrease the target organ damage, it is necessary to modify the risk factors in childhood.

2.8.1.4. Type 2 Diabetes mellitus and hyperuricemia

Type 2 diabetes is a complex disease, in which genetic factor, nutritional factors and environmental factors are involved. It is frequently but not invariably associated with overweight and obesity. The development of hyperglycaemia in type 2 diabetes results in an increase in fasting glucose production and a decrease postprandial glucose utilization.

The latter is the consequence of impaired glucose intolerance (i.e., impaired glucose induced insulin secretion, insulin resistance and increase endogenous glucose production). Cardiovascular disease is more prevalent in type 1 and type 2 diabetes and continues to be the leading cause of death among adults with diabetes. Diabetes coexists as a more severe risk factor with other associating risk factors, in particular with dyslipidemia or abnormal lipid profile. It increases cardiovascular risks due to increased levels of triglycerides, low levels of high-density lipoprotein cholesterol, and postprandial lipidemia. Dyslipidemia is mostly observed in patients with type 2 diabetes or metabolic syndrome **(Jaiswal et al., 2014).**

Insulin resistance, a well-known cardiovascular risk factor in adult life, has a strong association with childhood obesity. In a recent study on 208 obese children and adolescents, the rate of insulin resistance was 37% in boys and 27.8% in girls in the prepubertal period, while in the pubertal period the rates were 61.7% and 66.7%, respectively (**Kurtoğlu et al., 2010).** In another study of 710 obese children, **Invitti et al., (2003),** reported an overall prevalence of glucose intolerance of 4.5%. Obesity and the associated insulin resistance have significant influence on glucose metabolism, with hyper secretion of insulin and chronic hyperinsulinemia in obese adults as well as obese children, both without **diabetes (Li et al., 2006).** In a retrospective analysis of 1301 obese children, **Jin et al.** in **2011** reported the prevalence of type 2 diabetes as 2.2% and that of prediabetes as 19.6%. It is interesting to note that 52.2% of the prediabetic children had dyslipidemia and 20.8% had hypertension; this only reiterates the fact that there is clustering of cardiovascular risk factors in the setting of obesity **(Jin et al., 2011).**

In addition, association between metabolic syndrome and hyperuricemia is well established previously, studies have suggested increased uric acid as predictor of different factors related to metabolic syndrome. **Nakagawa et al**. in their work in 1729 adolescents provided an association between obesity and hyperuricemia and suggested that uric acid levels could be used as an indicator of obesity in early adolescence (**Nakagawa et al., 2005)**. **Zoppni et al.** in a prospective study with 2726 patients with type 2 diabetes suggested that high concentrations of uric acid were predictive of cardiovascular mortality in patients with type 2 diabetes mellitus **(Zoppini et al., 2009).** In another study on 462 subjects who had been free of disease for 10 years, **Dehghan et al.** found that the incidence of type 2 diabetes mellitus was higher in subjects with high uric acid levels and concluded that hyperuricemia was a risk factor for the development of such disease **(Dehghan et al., 2008).**

Diabetes is fastest growing disease in epidemic proportion. The health consequences and economic costs of the overweight, obesity and type 2 diabetes epidemics are enormous. Behavioural changes leading to increased body mass index is a major contributing factor to the rising incidence of diabetes. It was also observed from the above discussions that obesity to be a stronger factor that associated with diabetes.

2.9. Nutritional factors associated with coronary artery disease

2.9.1. Dietary fat

Macronutrient such as dietary fat includes diverse group water insoluble compounds (also referred to as lipids) that perform a variety of functions in the body as well as in food. Lipids deliver essential fatty acids that are vital for immune function and vision, carry fat soluble vitamins, comprise cell membrane, and provide energy for immediate and long term use. On other hand, most abundant type of fat in food (e.g., triglycerides) consists of a variety of fatty acids that differ in chain length and degree of saturation. Fatty acids are divided into two basic categories such as saturated and unsaturated fatty acids.

High Saturated and trans-fat (i.e., vegetable oil source) intake has been linked to an increased risk of cardiovascular disease (CVD), and this effect is thought to be mediated primarily by increased concentrations of low density lipoprotein cholesterol (LDL) cholesterol **(Parks & & Hellerstein, 2000; Siri & Krauss, 2005).** Saturated fat may also affect vascular function, perhaps by increasing the selective uptake of cholesterol in the arterial wall, resulting in increased atherogenesis in mouse models **(Seo et al., 2005).** In the acute postprandial phase following a meal enriched in saturated or polyunsaturated fat, HDL collected from individuals after a coconut meal compared with a safflower or unsaturated fat meal was associated with a 50–70% increase in intercellular adhesion molecule and vascular cell adhesion molecule **(Masterjohn, 2007).** Attribution of this effect specifically to the saturated fat of the coconut meal may, however, be confounded by the high concentrations of tocopherol found in coconut oil **(Nicholls et al., 2006).**

Replacing saturated and trans-fats with unsaturated fats, particularly manosaturated fats, appear to lower cholesterol (LDL) and reduce the risk for coronary artery disease (CAD). On the other hand, dietary fat can effect body weight regulation in verity of ways. First, dietary fat (9 kcal/gm) has more than doubled the energy of carbohydrate and protein kcal/g) **(Nicholls et al., 2006).**

Thus, reducing fat intake is an efficient way to reduce energy intake and create an energy deficit. This is the underlying concept behind low fat diets, reduced fat food and drugs that inhibits the absorption.

2.9.2. Carbohydrate

Like fat, various form of carbohydrate exists in food. Sugars (eg. glucose, fructose, sucrose) are the simplest form of carbohydrate. More complex carbohydrates are both digestible (i.e, starch) and non digestible (i.e., fibre). Carbohydrates play an important role in inducing satiety but primary functions of the dietary carbohydrate is to provide energy. Likely dietary fat, carbohydrate can positively and negatively affects weight regulation.

However, the effect of higher-carbohydrate diets, particularly those enriched in refined carbohydrates, coupled with the rising incidence of overweight and obesity, creates a metabolic state that can favour a worsening of the atherogenic dyslipidemia that is characterized by elevated triglycerides, reduced high density cholesterol (HDL), and increased concentrations of low density lipoprotein cholesterol (LDL) **(Park & Hellerstein, 2000; Siri & Krauss, 2005).**

Type of dietary carbohydrate, as measured by the glycemic index or glycemic load, has also been suggested to be a relevant determinant of coronary artery diseases (CAD) risk in some studies **(Beulens et al., 2007; Liu et al., 2000).** Glycemic index ranks carbohydrates according to their effects on blood glucose concentrations, and glycemic load is calculated from glycemic index, carbohydrate content, and actual or estimated intake of food items. High glycemic load from refined carbohydrates was shown to be associated with an increased cardiovascular disease (CHD) risk independently of known risk factors in the Nurses' Health Study (**Liu et al., 2000**) and was more recently shown to be associated with an increased risk of CHD in a prospective cohort study of.15, 000 middle-aged women (**Beulens et al., 2007**.

2.9.3. Vitamin D

Vitamin D deficiency is widely prevalent in the worldwide **(von der Recke et al., 1999).** There is increasing evidence that a low vitamin D status may be an important and hitherto neglected factor of cardiovascular disease.

The contractile properties of cardiac cells are mainly controlled by the direct interaction between calcium, the contractile proteins, actin and myosin, and the intracellular handling of calcium. The extracellular calcium homeostasis affected by vitamin D levels impact the intracellular calcium and can indirectly influence cardiac cell contractility **(Weber et al. 2008).** Calcitriol, the active vitamin D form (1, 25-dihydroxyvitamin D), impacts the function of almost all body cells including cardiac cells, endothelial cells, and vascular smooth muscle cells through the cytosolic vitamin D receptor (VDR). This impact varies among these cells but is crucial in cardiac cells as they depend exclusively on the circulating blood concentration of calcitriol secondary to the absence of an enzymatically active 25-hydroxyvitamin D-1 [alpha]-hydroxylase system **(Zittermann et al., 2008; Hewison et al., 2004)**. The absence of VDR receptors, therefore, has many adverse effects on cardiac cells. Isolated cardiac cells from VDR knockout mice are noted to have accelerated rates of contraction and relaxation that are not affected by calcitriol levels when compared to control mice **(Tishkoff et al., 2008).** Furthermore, cellular hypertrophy of heart myofibrils resulting in cardiomegaly was noticed in VDR knockout mice **(Rahmn et al., 2007).** This can be explained by the fact that tissue inhibitors of matrix metalloproteinases were significantly under-expressed in VDR knockout mice compared to control mice **(Rahmn et al., 2007).**

Many studies show an association of vitamin D deficiency with well-established atherosclerosis risk factors, including obesity, glucose intolerance, metabolic syndrome, and hyperlipidemia **(Michos et al., 2008; Anderson et al., 2010; Martins et al.; 2007)**. The presumed role of vitamin D in the pathogenesis of coronary artery disease (CAD) is not necessarily linked only to atherosclerosis, but may involve vascular calcification. The basis of this presumption comes from patients with end-stage renal disease.

As a consequence of reduced renal calcitriol synthesis, in addition to other factors, secondary hyperparathyroidism emerges in the early stages of chronic kidney disease **(Drüeke et al., 2003).** In patients with end-stage renal disease, secondary hyperparathyroidism is considered an important risk factor in the pathogenesis of coronary artery disease (CAD) leading to vascular calcification **(Rostand & Drüeke, 1999; Welles et al., 2014).**

In hemodialysis patients, the use of active vitamin D and synthetic vitamin D analogs has been shown to reduce the risk of death from cardiovascular disease **(Shoji et al., 2004; Wannamethee et al., 2014).** In the general population, the presence of vascular calcification is a predictor of poorer five-year survival rates **(Chung et al., 2015).** Interestingly, the use of calcitriol was found to be inversely correlated with the extent of vascular calcification, independently from other risk factors for ischemic heart disease **(Chung et al., 2015; Watson et al., 1997)**. So, it is revealed from the above discussion that a strong relationship between nutrition and coronary artery disease. Thus maintenance of proper diet is important to reduce coronary artery disease risk of an individual.

Materials & Methods

Chapter III

3.1. Introduction

This chapter describes selection of the site and subjects, selection of the variables, instruments used and their reliability, tester competence, reliability and variability of the tests, procedures of administering the tests and statistical techniques for analyzing the data also delimitations and limitations of the study.

3.2. Selection of Site and Subjects

This cross-sectional study was carried out in different Urban Private Schools of mainly three districts (Paschim Medinipur, Bankura and Purba Medinipur) of State of West Bengal of India during the period of 2012 to 2015. In this study a total 1450 healthy school going boys having age range of 5 to 12 years from middle socio-economic class Bengali families were primarily selected by standard questionnaire method which had following inclusion criteria:

i) The subjects should not have any previous or present history of heredity or family related cardiovascular disease.

ii) The subjects won't have any diagnosed previous history of cardiovascular disease and or any other chronic diseases like asthma, nephropathy, hepatopathy and others before selection.

iii) The subjects won't be under any medication for chronic diseases or undergoing medical treatment.

The socio-economic class of the families were determined following the guidelines proposed by **Agarwal (2008)**. Among 1450 boys, 267 boys did not agree to participate for volunteered study. Hence, 1183 (with a response rate 81.58%) boys were primarily investigated for the present study with following exclusion criteria:

According to WHO growth chart **(de'Onis et al., 2008)** on the basis of BMI-age-boys Z-scores, the boys those were found underweight (n = 147) were excluded. Finally, 1036 boys were selected and data obtained from them in connection with the study.

The selected boys were divided according to their chronological age into four groups such as 5 - < 7 years, 7 - < 9 years, 9 - < 11years, 11- <13 years and each age group was further categorised in three sub divisions, normal weight boys, overweight boys and obese boys as recommended by **WHO (2007)** according to their BMI-age-boys-Z scores (i.e., normal weight: - 2SD > BMI Z score ≤ + 1SD, overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD).

The age of the boys were determined from their date of birth as recorded in their school register. The boys were randomly sampled from their populations from different Private Sector Schools of three different district towns of sate of West Bengal, India i.e., Midnapore (Pachim Medinipur district), Bankura (Bankura district) & Panskura (Purba Medinipur district).

Ethical approval and prior permission were obtained from the Institutional Ethics Committee before commencement of the study and the experiment was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. Prior to the experimental trial each protocol was explained verbally in local language (Bengali) to the subjects and school authorities and informed consent was obtained from the participants. For this study, parents of the participating boys and also head of the school were asked to give written approval for their boys to be involved in this research programme. The measurements were taken on the same day or another as per their agreement by fixing prior appointments. The number of participants selected for different experiments in this study is mentioned in respective chapters and tables.

3.3 Selection of variables

Keeping in view the feasibility criteria and the relevance of the variables in the present study several selected anthropometric, motor quality, physiological, biochemical and nutritional parameters were studied as effect of childhood obesity on motor quality development and its relation with risk factors for development of coronary artery disease. The measurements include height, body weight, waist circumference, hip circumference, thigh circumference as anthropometric parameters body mass index (BMI), waist to hip ratio (WHR) and waist thigh ratio (WTR) were calculated which represents the degree obesity. On the other hand, motor quality parameters included such as hand reaction time (HRT), foot reaction time (FRT) , speed of movement (SOM) , agility, 30 meter speed, vertical jump test (VJT) scores and standing long jump test (SLJT) scores . The selected biochemical parameters included fasting serum lipids i.e., total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC) and low density lipoprotein cholesterol (LDLC). The ratio of total cholesterol to high density lipoprotein cholesterol (TC ÷ HDLC) was also calculated. Other two biochemical variables such as fasting blood glucose and uric acid were also determined. The selected physiological variables included resting pulse rate, resting respiratory rate, systolic blood pressure (SBP) and diastolic blood pressure (DBP) and physical fitness index (PFI). The selected nutritional parameters included daily dietary intake carbohydrate, protein, fat, calorie, vitamin A, ascorbic acid, vitamin D, vitamin B12, folic acid, iron, calcium and zinc. The selected variables for the present study and their units are shown in the Table 3.1.

The instruments used in the present study are as follows:

- A Calibrated Anthropometric rod for height measurement.
- Electronic portable weighing machine for weight measurement.
- Harpenden skinfold calliper for measurements of skinfold thickness.
- Steel measuring tape for measurement of circumference.

- ❖ Centrifuge and Semi auto-analyzer (Vitalab 31, Vital scientific, USA) for serum lipids estimation.
- ❖ Mercury sphygmomanometer for measurement of systolic and diastolic blood pressure.
- ❖ A 14 inches tool for conducting Harvard's Steps Test for determination of physical fitness index (PFI).

Table 3.1 Selected variables and their units

Name of the variables	Measurement units
Anthropometric Obesity Parameters	
Height	cm
Body weight	kg
Body Mass Index (BMI)	$kg.m^{-2}$
Waist Circumference (WC)	cm
Hip Circumference (HC)	cm
Thigh circumference (TC)	cm
Waist to Hip Ratio (WHR)	-
Waist to Thigh Ratio (WTR)	-
Motor Quality Parameters	
Hand Reaction Time (HRT)	sec
Foot Reaction Time (FRT)	sec
Speed of Movement (SOM)	sec
Agility (4 × 10 Meter Shuttle Run)	sec
30 Meter Sprint	sec
Vertical jump test (VJT)	cm
Standing long jump test (SLJT)	cm
Physiological Parameters	
Pulse Rate	$beats.min^{-1}$
Respiratory Rate	$cycle.min^{-1}$
Systolic Blood Pressure (SBP)	mmHg

Diastolic Blood Pressure (DBP)	mmHg
Biochemical Parameters’	
Serum Lipids	
Total cholesterol (TC)	$mg.dl^{-1}$
Triglycerides	$mg.dl^{-1}$
High Density Lipoprotein Cholesterol (HDLC)	$mg.dl^{-1}$
Low Density Lipoprotein Cholesterol (LDLC)	$mg.dl^{-1}$
Ratio of TC to HDLC (TC ÷ HDLC)	-
Blood glucose	$mg.dl^{-1}$
Uric acid	$mg.dl^{-1}$
Nutritional Parameters	
Macronutrient	
Carbohydrate	gm/day
Protein	gm/day
Fat	gm/day
Calorie	Kcal/day
Micronutrient	
Vitamin	
Vitamin A	µg/day
Ascorbic acid	mg/day
Vitamin D	µg/day
Vitamin B12	µg/day
Folic acid	µg/day
Minerals	
Iron	mg/day
Calcium	mg/day
Zinc	mg/day

3.4. Tester competence

To ensure that the researcher was well versed with the techniques of conducting the anthropometric measurements, motor quality measurement, physiological measurement, the researcher had a number of practice sessions in the testing procedure. Tester reliability was established by the test-reset method, whereby, consistency of the results was obtained by product-moment correlation by using the formula of **Clarke & Clarke (1970).**

The data collected twice from a random selection of ten subjects through pilot study, were correlated to obtain the reliability of the data for the selected anthropometric parameters, motor quality parameters, physiological parameters. The obtained correlation coefficients between two sets of data by test and retest method in various measurements have been presented in Table 3.2.

Table 3.2. Coefficient of reliability

Variables	Correlation Coefficients
Height	0.98
Body weight	0.97
Skinfold thickness measurement	0.90
Circumference	0.92
Reaction time	0.95
Blood pressure	0.94
Pulse rate	0.97
Respiratory rate	0.95

Since very high correlation values of 0.90 to 0.98 were obtained for the variables, the competency of the tester to administer the tests established.

3.5. Reliability of instruments used for anthropometric measurements, motor quality determination, physiological test, biochemical analyses and nutritional assessment

The anthropometric rod, skinfold calliper, steel measuring tape, reaction timer, centrifuge, semi auto-analyze and sphygmomanometer were procedure from reliable companies. All the instruments were calibrated before use. The instruments were available and were in frequent use in routine testing and different research projects.

3.6. Reliability and validity of anthropometric measurements, motor quality determination, physiological test, biochemical analyses and nutritional assessment

The tests and measurements of the present study were conducted according to the standard procedures, having established reliability and validity, adopted by the researcher. Thus the measurements used were valid.

3.7. Procedure for conducting anthropometric measurement, motor quality determination, physiological test, biochemical analyses and nutritional assessment

For the selection of subject, collection of anthropometric, physiological and nutritional data five research assistants were recruited and trained up for the field work. On the other hand, two trained BP.Ed 'student' assisted to conduct the motor performance tests. After the collection and evaluation of anthropometric, motor quality, physiological and nutritional parameters the subjects requested to donate the blood for estimation of biochemical parameters on a pre-arranged date. The subjects were requested to be present at their school about 9 a.m with fasting and non-exercising condition for preceding ten hours **(Ponjee et al., 1996)**.

3.7.1. Conductance of anthropometric measurement

3.7.1.1. Height (cm)

Height was measured by adopting standard procedure **(Sodhi, 1991).** Body height was measured by the calibrated anthropometric rod procedure from reliable company. The stood bare foot and erect with heels together and arms hanging naturally by the sides. The distance from the floor to the highest position of the head (vertex) was measured the help of the anthropometric rod, which indicating subjects' height. The height was recorded to the nearest centimetre.

3.7.1.2. Body weight (kg)

Body weight was measured by adopting standard procedure **(Sodhi, 1991).** Body weight of the subject was taken by the calibrated electronic portable weighing machine. The boys wearing vest and shorts stood at the centre of the weighing machine looking straight. The body weight was recorded to the nearest kilogram.

3.7.1.3. Body mass index ($kg.m^{-2}$)

BMI was calculated as the body weight in kilogram divided by height in square meters ($kg.m^{-2}$). Identification of overweight and obesity in the boys were performed by plotting BMI value on the WHO growth chart to determined the corresponding BMI-age-boys Z scores **(WHO, 2007)** and also following the proposed guidelines by **Cole et al., (2002)** for children with BMI $\geq 95^{th}$ percentile are obese and those with BMI $\geq 85^{th}$ percentile but $< 95^{th}$ percentile are defined overweight.

3.7.1.4. Measurement of circumferences (cm)

All the selected circumferences in the present study were measured according to the recommendation of **WHO (1989).**

Waist circumference was measured midway between the lower rib margin and the iliac crest.

Hip circumference was measured horizontally at the level of gluteal muscle (at maximum circumference).

Thigh circumference was measured as the horizontal girth at the level of the gluteal fold on the right thigh.

In all measurements the subjects were standing with their weight evenly balanced on both feet and the distance between the feet about 30 cm apart. The subjects were asked to breathe normally and, at the time of measuring to breathe out gently.

Calculation of Waist Hip Ratio (WHR) and Waist Thigh Ratio (WTR)

$$WHR = C_W / C_H$$

Where C_W = Waist circumference, C_H = Hip circumference

$$WTR = C_W / C_T$$

Where C_W = Waist circumference, C_T = Thigh circumference

3.7.1.5. Measurement of body fat percentage

For measurement of body fat percentage, skinfold thickness were measured at the right side on the triceps and sub-scapula with the boys standing in the proper erect posture according to the methods proposed by **Eston et al. (1995)** using Holtain skinfold callipers which consists of accurately calibrated dial which indicates in millimetre. To eliminate errors, reading was made between three to four seconds when essentially all compression has taken place and the measurements were taken. If this precaution were not taken, the skinfold would have gradually decreased because of the tissues being squeezed out from the jaw of the calliper.

Triceps skinfold thickness (mm)

This measurement was taken at the midpoint between the acromion and olecranon processes on the posterior aspect of the arm. The subject stood with the arms hanging down freely. The triceps skinfold thickness was recorded to the nearest millimetre.

Subscapular skinfold thickness (mm)

This skinfold was measured by taking a fold on a diagonal line coming from a vertebral border to 1 to 2 centimetres from the inferior angle (about 45^{o}) of the scapula. The subscapular skinfold thickness was recorded to the nearest millimetre.

Computations of body fat% of boys were done using triceps and subscapular equation that is developed by **Slaughter et al. (1988)**.

The equation is as follows:

Body fat % for boys = 783*(triceps skinfold thickness + subscapular skinfold thickness) -1.7

3.7.2. Measurement of motor quality parameters

3.7.2.1 Determination of hand reaction time (HRT) (sec)

The boys sitting with his fore forearm and hand were resting comfortably on the table. The tips of the thumb and index finger were held in a ready to pinch position about 3 or 4 inches beyond the edges of the table. The upper edges of the thumb and index finger were in a horizontal position. Tester holds the stick timer close to the top in between the boy's thumbs and index finger. The boys were directed to look at the concentration zone and were told to react by catching the stick when it is released. The boys were not allowed looking at the tester's hand and not to move his hand up or down while attempting to catch the falling stick. Each drop was preceded by command of "ready". The boys were allowed twenty trials, among these mean of middle ten scores was considered. This procedure was according to the method proposed by **Johnson & Nelson (1988)**.

R.T. = √ 2×Distance the stick (timer) falls (in cm)/acceleration gravitional constant (981)

Where R.T. = Reaction time (sec)

3.7.2.2. Determination foot reaction time (FRT) (sec)

The boys were sitting on a table which was about 1 inch from the wall. With their shoes off, each boy positioned his foot so that the ball of the foot was held about 1 inch from the wall with the heel resting on the table about 2 inches from the edges. The tester holds the reaction timer next to the wall so that it hangs between the wall and the boy's foot with the base line opposite to the end of the big toe. The boys looked at the concentration zone and were told to reacts, when the timer would be dropped, by pressing the stick against the wall with the ball of his foot. The boys were allowed twenty trials, among these mean of middle ten scores were considered. This procedure was according to the method proposed by **Johnson & Nelson (1988)**

R.T. = √ 2×Distance the stick (timer) falls (in cm)/ acceleration gravitional constant(981)

Where R.T. = Reaction time (sec)

3.7.2.3. Determination of speed of movement (SOM) (sec)

The boys were sitted on table with hands resting on the edges of the table. The palms were facing one another with the inside border of the little fingers along two lines which were marked on the edges of the table 12 inches apart. The tester holds the timer near its top so that it hangs midway between the boy's palms. The base line was positioned so it can level with the upper borders of the boy's hands. After the introductory command was given, the timer (ruler) was released and the boys clapped the hands together. The boys must be careful not to allow his hands to move up or down when he was clapping the hands together. This procedure was according to the method proposed by **Johnson & Nelson (1988)**. Each boys was allowed twenty trials, among these mean of middle ten scores were considered.

R.T. = √ 2×Distance the stick (timer) falls (in cm)/acceleration gravitional constant(981)

Where R.T. = Reaction time (sec)

3.7.2.4. 30 meter sprint (sec)

The boys were instructed to perform 30 meter sprint (flying start) and the reading were taken in seconds by stop watch. For the measurement, the sprint was performed thrice. From there, best of one was accepted for analysis. This method was proposed by **Vieira et al. (2013).**

3.7.2.5. Agility (4 × 10 meter shuttle run) (sec)

This test helps to know about the integral evaluation of speed, agility and coordination. The boys made four shuttle runs as fast as possible between 2 lines 10 meters apart. At each end the boys placed or picked up an item (a wooden block) beside the line on the floor. This procedure followed the method proposed by **España-Romero et al., (2010)**.

3.7.2.6. Vertical jump test (VJT) (cm)

This test helps to know about the muscular strength. The subject was asked to stand erect facing the wall. His dominant hand's fingertips reached to a maximum height on the wall without lifting the heels so as to mark his maximum reach point. The fingertips were rechalked. With the chalked hand side towards the wall, a vertical jump was performed by the subject to make another mark at the maximum height of the jump. The subject was not allowed to run or hop. The subject was given two trials and from there, the best one performance was considered. This procedure followed the method proposed by **Kansal (2008).**

3.7.2.7. Standing long jump test (SLJT) (cm)

This test is also called the Broad Jump. It is very common test for the measurement of the explosive power of the legs. The subject was stand behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Two trials were allowed, best one attempt was considered. This procedure followed the method proposed by **Kansal (2008).**

3.7.3. Determination of Physiological Parameters

3.7.3.1. Blood pressure (mmHg)

Blood pressure was measured using standard auscultatory method in sitting position after rest period of the subjects. Blood pressure was measured by mercury sphygmomanometer. 'Calf' of the instrument was wrapped on the upper arm of the subjects mouthpiece of the stethoscope was placed over the brachial artery. Pressure was raised to maximum and then gradually released. The systolic blood pressure (SBP) was recorded at the appearance of first 'Korotkoff' sound and the diastolic blood pressure (DBP) was assured at the disappearance of the 'Korotkoff' sounds.

3.7.3.2. Pulse rate (beats.min^{-1})

Pulse rate was measured by using a stop watch in sitting position after rest period of the subjects. The tips of the three fingers were placed on the radial artery at wrist. The pulse count was continued for 60 seconds duration. The number of beats counted was recorded as beats per minute (bpm).

3.7.3.3. Respiratory rate (cycle. min^{-1})

Resting respiratory rate was determined by the mentioned by **William et al. (2006)**. Resting respiratory rate was measured by observing subject's chest rising and falling, placing the hand on subjects belly and feeling the rising and falling. Respiratory rate was counted by using a stop watch in sitting position after rest period of the subjects. The respiratory rate count was continued for 60 seconds duration. The respiratory rate was recorded as cycle per minute (cpm).

3.7.3.4. Physical fitness index (PFI)

PFI was determined by Modified Harvard Step Test (HST – III). This test was done on Modified Harvard Steps (HST-III) according to the method developed by **Brouha & Ball (1952)** for applicable to school children. The method is as follows:

Every boy studied was advised to step up on the modified Harvard steps of 14 inches height once in every two seconds (i.e., 30 times per minute) for 3 minutes, a total of 90 steps. Post exercise recovery pulse was recorded as:

a) Pulse Rate 1– 2 min after exercise

b) Pulse Rate 2 – 3 min after exercise

c) Pulse Rate 3 – 4 min after exercise

$$\text{PFI} = \frac{\text{Duration of exercise in seconds}}{2 \times (\text{recovery pulse 1st+2nd+3rd minutes})} \times 100$$

3.7.4. Determination of Blood Parameters

Fasting blood samples (12 to 14 hours fasting) were collected from 442 selected subjects to determine the serum lipids, glucose and uric acid level. About 5ml of blood was collected from antecubital vein of all individuals by 5 ml syringe and then allowed to clot, centrifuge and the supernatant serum was kept frozen at -20^{0}c until analysis. Sample were later analysed for serum TC, HDLC, LDLC, TG, blood glucose and uric acid levels. Reagents of the test kits were stored and used as per the guidelines mentioned in the test kits used.

3.7.4.1. Analysis of serum lipids

3.7.4.1.1. Total cholesterol (TC)

Total cholesterol (TC) was analyzed using a test kit (DiaSys, USA). The analysis was carried out according to **Richmond (1973).**

Principle

Cholesterol esterase hydrolyses cholesterol esters into free cholesterol and fatty acids. In the second reaction cholesterol oxidase converts cholesterol to cholesterol-3-one and hydrogen peroxide oxidatively couples with 4-aminoantipyrine and phenol to reduce red quinoneimine. The intensity of the red color is proportional to the amount of cholesterol present in the specimen.

$$\text{Cholesterol ester} + H_2O \xrightarrow{\text{Cholesterol esterase}} \text{Cholesterol} + \text{fatty acids}$$

$$\text{Cholesterol} + O2 \xrightarrow{\text{Cholesterol oxidase}} \text{Cholesterol-3-one} + 4H_2O$$

$$2H_2O + \text{4-aminoantipyrine} + \text{Phenol} \xrightarrow{\text{Peroxidase}} \text{Red Quinoneimine} + H2O$$

Reagent component and concentration

The test reagent supplied with the kit contained the following components with the concentration with the concentration given as follows:

Good's Buffer (P^H 6.7)	50.0 mmol/l
Phenol	5.0 mmol/l
4-aminoantipyrine	0.3 mmol/l
Cholesterol esterase	≥ 200.0 U/l
Cholesterol oxidase	≥ 100.0 U/l
Peroxidase	≥ 3.0 U/I

Standard

The standard cholesterol supplied with kit contained 200 mg/dl of cholesterol.

Procedure

In a test tube marked 'Sample' 1000 µl of test reagent of the kit was taken and to this 10 µl of serum. In another test tube marked 'Standard' 1000 µl of the test reagent and 10 µl of the standard cholesterol (200mg.dl^{-1}) of the kit were taken. 'Blank' was prepared by taking 1000 µl of test reagent of the kit in a test tube. The content of the three test tubes were mixed well and incubated at 37^{o} C for five minutes after the incubation 546nm autoanalyzer (Vitalab 3, Vital Sientific, USA).

Calculation

$$\text{Total Cholesterol (mg. dl}^{-1}) = \frac{\text{Absorbance of sample}}{\text{Absorbance of Standard}} \times \text{Concentration of standard (200)}$$

3.7.4.1.2. High density lipoprotein cholesterol (HDLC)

High density lipoprotein cholesterol (HDLC) was analyzed using the test kit (Randox Laboratories, USA). The analysis was carried out according to **Lopes-Virella et al. (1977).**

Principle

High density lipoprotein cholesterol is separated from other lipoprotein fractions by treating serum with plasma with phosphotungstic acid and magnesium chloride. High density lipoprotein cholesterol remains in solution while all other lipoprotein fractions are precipitated. Cholesterol content of the solution is then estimated by enzymatic method.

Reagent component and concentration

The reagents supplied with test kit contained the following component with the concentration given as follows:

Precitating reagent

Phosphotungstic acid	0.55 mmol/l
Magnesium chloride	25.0 mmol/l

Test reagent for estimation of cholesterol

Good's Buffer (P^H)	50.0 mmol/l
Phenol	5.0 mmol/l
4-aminoantipyrine	0.3 mmol/l
Cholesterol esterase	≥ 200.0 U/l
Cholesterol oxidase	≥ 100.0 U/l
Peroxidase	≥ 3.0 U/I

Standard

The HDL cholesterol standard solution contained 50 mg/dl of cholesterol.

Procedure

At first separation of HDLC was done by taking 200 µl of plasma and 500 µl of precipitating reagent of the kit containing phosphotungstic acid and magnesium chloride in a microcentrifuge tube. They were mixed well and kept at room temperature for ten minutes. Then the mixture was centrifuge (RM12C Microcentrifuge, REMI Equipment, and India) at 4000 rpm for ten minutes. The clear supernatant was taken out immediately by the following procedure-

In a test tube marked 'Sample' 1000 µl of test reagent of the kit was taken and added to this 100 µl of the the supernatant. In another test tube marked 'Standard' 1000 µl of the test reagent and 100 µl of the standard HDL cholesterol (50 $\mu l.dl^{-1)}$ of the kit were taken 'Blank' was prepared by taking 1000 µl of the test reagent of the kit in a test tube. The contents of the three test tubes were mixed well incubated at 37^{O}C for five minutes. The absorbance of the 'Sample' and 'Standard' were measured against 'Blank' at 546 nm in semi autoanalyzer (Vitalab 31, Vital Scentific, USA).

Calculation

$$\text{HDLC (mg/dl}^{-1}) = \frac{\text{Absorbance of Sample}}{\text{Absorbance of Standard}} \times \text{Concentration of Standard} \times \text{Dilution Factors}$$

$$= \frac{\text{Absorbance of Sample}}{\text{Absorbance of Sample}} \times 50 \times 3.5$$

3.7.4.1.3. Triglycerides

Triglyceride was analyzed using the test kit (DiaSys, USA). The analysis was carried out according to **Koditschek & Umbreit (1969).**

Principle

Lipoprotein lipase hydrolyzes serum triglycerides to glycerol and free fatty acids. The liberated glycerol is converted to glycerol-3-phosphate in the presence of ATP and glycerokinase. Glycerol-3-phosphate is oxidised by glycerol-3-phosphate oxidase to yield hydrogen peroxide. Hydrogen peroxide thus generated reacts with 4-aminoantipyrine and 4-chlorophenol under the catalytic action of peroxide to form a colored complex. The intensity of the color developed is proportional to triglycerides concentration and is measured photometrically at 546 nm (530-570).

$$\text{Triglycerides} \xrightarrow{\text{Lipoprotein lipase}} \text{Glycerol + Free fatty acids}$$

$$\text{Glycerol + ATP} \xrightarrow{\text{Glycerokinase}} \text{Glycerol-3phosphate + ADP}$$

$$\text{Glycerol-3-phosphate} + O_2 \xrightarrow{\text{Glycerol-3-phosphate oxidase}} \text{Dihydroxy acetone phosphate} + H_2O_2$$

$$2H_2O_2 + \text{4-amioantipyrine + 4-chlorophenol} \xrightarrow{\text{Peroxidase}} \text{Red Quinoneimine} + 4H_2O$$

Reagent components and concentration

The test reagent supplied with the kit contained the following components with the concentrations given as follows:

Good's Buffer (P^H)	50.0 mmol/l
4-chlorophenol	4.0 mmol/l
ATP	2.0 mmol/l
Mg_2	15.0 mmol/l
Glycerokinase	≥ 0.4 U/l
Peroxidase	≥ 2.0 U/l
Lipoprotein lipase	≥ 4.0 U/l
4-aminoantipyrine	0.5 mmol/l
Glycerol-3-phosphate	≥ 1.5U/l

Standard

The standard triglycerides supplied with the kit contained 200 mg/dl of triglycerides.

Procedure

In a test tube marked 'Sample' 1000 µl of test reagent of the kit was taken and added to this 10 µl of serum. In another test tube marked 'Standard' 1000 µl of the test reagent and 10 µl of triglycerides standard (200mg.dl^{-1}) of the kit were taken. 'Blank' was prepared by taking 1000 µl of the test reagent of the kit in a test tube. The contents of the three test tubes were mixed well and incubated at 37 ^{O} C for five minutes. After incubation the absorbance of the 'Sample' and 'Standard' were measured against 'Blank' at 546 nm in semi autoanalyzer (Vitalab, Vital Scientific, USA).

Calculation

$$\text{Triglycerides (mg.dl}^{-1}\text{)} = \frac{\text{Absorbance of Sample}}{\text{Absorbance of Standard}} \times \text{Concentration of Standard}$$

$$= \frac{\text{Absorbance of Sample}}{\text{Absorbance of Standard}} \times 200$$

3.7.4.1.4. Low density lipoprotein cholesterol (LDLC)

The low density lipoprotein cholesterol (LDLC) level ($mg.dl^{-1}$) was calculated according to the formula of **Friedewald et al. (1972).** The formula is valid at the triglycerides level not exceeding 400 $mg.dl^{-1}$. The formula is as follows:

$$LDLC = (TC) - \left(\frac{\text{Triglycerides}}{5}\right) - (HDLC)$$

3.7.4.2. Analysis of serum glucose

Serum glucose was analyzed using the test kit (CREST BIOSYSTEM, India). The analysis was carried out according to **Trinder (1969).**

Principle

Glucose is oxidised and hydrogen peroxide in the presence of glucose oxidase. Hydrogen peroxidase. Hydrogen peroxidase further reacts with phenol and 4-aminoantipyrine by the catalytic action of peroxidase to form a red coloured quinoneimine dye complex. Intensity of the coloured is directly proportional to the amount of glucose present in the sample.

$$\text{Glucose} + O_2 + H_2O \xrightarrow{\text{Glucose Oxidase}} \text{Gluconate} + H_2O_2$$

$$H2O2 + \text{4Aminoantipyrine} + \text{Phenol} \xrightarrow{\text{Peroxidase}} \text{Red Quinoneimine} + H_2O$$

Reagent components and concentration

The test reagent supplied with the kit contained the following components with the concentrations given as follows:

Contents	**2 × 150 ml**	**3 × 150 ml**	**1000 ml**
L1: Glucose Reagents	2 × 150 ml	3 × 150 ml	1000 ml
S: Glucose Standard	5 ml	5 ml	5 ml

Procedure:

Wavelength	546 nm
Temperature	37^{O}C for 10 minutes
Light Path	1 cm

Pipetting into dry clean tubes labelled as Blank (B), Standard (s) and Test (T):

Addition Sequence	**B** (ml)	**S** (ml)	**T** (ml)
Glucose Reagent (L1)	1.0	1.0	1.0
Distilled water	0.01	-	-
Glucose Standard (S)	-	0.01	-
Sample	-	-	0.01

The contents of the three test tubes were mixed well and incubated at 37^{O}C for 10 minutes. After incubation the absorbance of the 'Test' and 'Standard' were measured against 'Blank' at 546 nm in semi autoanalyzer (Vitalab, Vital Scientific, USA).

$$\text{Glucose} + O_2 + H_2O \xrightarrow{\text{Glucose Oxidase}} \text{Gluconate} + H_2O_2$$

Peroxidase

$H2O2$ + 4Aminoantipyrine + Phenol ⟶ Red Quinoneimine + H_2O

Reagent components and concentration

The test reagent supplied with the kit contained the following components with the concentrations given as follows:

Contents	**2 × 150 ml**	**3 × 150 ml**	**1000 ml**
L1: Glucose Reagents	2 × 150 ml	3 × 150 ml	1000 ml
S: Glucose Standard	5 ml	5 ml	5 ml

Procedure

Wavelength	546 nm
Temperature	37^{O}C for 10 minutes
Light Path	1 cm

Pipetting into dry clean tubes labelled as Blank (B), Standard (s) and Test (T):

Addition Sequence	**B** (ml)	**S** (ml)	**T** (ml)
Glucose Reagent (L1)	1.0	1.0	1.0
Distilled water	0.01	-	-
Glucose Standard (S)	-	0.01	-
Sample	-	-	0.01

The contents of the three test tubes were mixed well and incubated at 37^{O}C for 10 minutes. After incubation the absorbance of the 'Test' and 'Standard' were measured against 'Blank' at 546 nm in semi autoanalyzer (Vitalab, Vital Scientific, USA).

Calculation

$$\text{Total glucose (mg.dl}^{-1}\text{)} = \frac{\text{Absorbance Test}}{\text{Absorbance of Standard}} \times \text{Concentration of Standard (100)}$$

3.7.4.3. Analysis of serum uric acid

Serum uric acid was analyzed using the test kit (CREST BIOSYSTEM, India). The analysis was carried out according to **Trinder (1969).**

Principle

Uricase converts uric acids to allantonin and hydrogen peroxide. The hydrogen peroxide formed further reacts with a phenolic compound and 4 aminoantipyrine by the catalytic action of peroxidase to form a red coloured quinoneimine dye complex. Intensity of the colour formed is directly proportional to the amount of uric present in the sample.

$$\text{Uric acid} + H_2O \xrightarrow{\text{Uricase}} \text{Allantonin} + H_2O$$

$$\text{H2O2} + \text{4 Aminoantipyrine} + \text{Phenolic compound} \xrightarrow{\text{Peroxidase}} \text{Red Quinoneimine dye} + H_2O$$

Reagent components and concentration

The test reagent supplied with the kit contained the following components with the concentrations given as follows:

Contents	25 ml	75 ml	2 × 75 ml	2 × 150 ml
L1:Buffer Reagents	20 ml	60 ml	2 × 60 ml	2 × 120 ml
L2:Enzyme Reagents	5 ml	15 ml	2 × 15 ml	2 × 30 ml
Uric acid Standard (8 $mg.dl^{-1}$)	5 ml	5 ml	5 ml	5 ml

Reagents Preparation

Working reagent: Pouring the contents of 1 bottle of L2 (Enzyme Reagent) into 1 bottle of L1 (Buffer Reagents). This working reagents was stable for 4 weeks when stored at 2-8^{o}C.

Procedure

Wavelength	546 nm
Temperature	37^{O}C for 10 minutes
Light Path	1 cm

Pipetpting into dry clean tubes labelled as Blank (B), Standard (s) and Test (T)

Addition Sequence	B (ml)	S (ml)	T (ml)
Working reagents	1.0	1.0	1.0
Distilled water	0.02	-	-
Uric acid Standard (S)	-	0.02	-
Sample	-	-	0.02

The contents of the three test tubes were mixed well and incubated at 37^{O}C for 10 minutes. After incubation the absorbance of the 'Test' and 'Standard' were measured against 'Blank' at 546 nm in semi autoanalyzer (Vitalab, Vital Scientific, USA)

Calculation

$$\text{Uric acid } (mg.dl^{-1}) = \frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}} \times \text{Concentration of Standard (8)}$$

3.8. Nutritional Assessment by diet

Nutritional status of the children was evaluated by questionnaire method. For this purpose 24 hours recall method was employed **(Swaminathan, 1999**). The quantity of different food items taken by the subjects in last 24 hours was recorded in the standard format. The process was repeated for three consecutive days and average of the each food item taken was computed. From the average quantity of the food consumed by the subjects, the amounts of energy, carbohydrate, protein, fat, minerals and vitamins were calculated by using ICMR **(ICMR, 2009)** food composition table.

3.9. Statistical Analysis

Data analysis was performed using the statistical packages IBM SPSS, version 20 SPSS, (Chicago, USA) and Origin 8.1. Mean, standard deviation (± SD), median, range, percentile ranking were obtained for all the selected anthropometric obesity, motor quality, physiological and biochemical parameters of three body weight categories in four age groups of boys. One way ANOVA was conducted to examine any differences in each variable among three body weight categories. Post hoc multiple comparison tests (Scheffe's F test) were performed for each of the variables to see the significance of the differences in each pair of groups where F values in one way ANOVA were significant. Pearson product moment correlation coefficients (r) were performed to examine the relationship of different anthropometric variables and age with the motor quality, physiological, biochemical variables. The 'standard partial regression or standardized coefficient' of multiple linear regression analyses were used to show the independent relationship of BMI, fat percentage, waist hip ratio and waist to thigh ratio with motor quality, nutritional biochemical, and physiological variables.

3.10. Delimitation of the study

1. All selected subjects were Bengali by race and their foods habits were similar. The study was carried out in three different surrounding districts such as Bankura, Paschim Medinipur and Purba Medinipur of state of West Bengal, India

2. BMI, waist circumference, hip circumference, thigh circumference, WHR, WTR, body fat %, total cholesterol, HDL cholesterol, LDL cholesterol, systolic blood pressure, diastolic blood pressure were included in the present study for evaluating most recognized and important risk factors for coronary artery disease i.e., obesity parameters, adverse blood lipids and high blood pressure.

3. Resting heart rate and respiratory rate were included in the present study. Resting heart rate is important indicator of cardiovascular health because resting heart rate has gained attention as a simple but powerful marker of cardiovascular health. On the other hand, obese boys tend to have higher respiratory rates and lower tidal volumes and total respiratory system compliance is reduced.

4. Physical fitness index were measurement indirect method reflects individual's physical fitness status. So, analysis of physical fitness index was included in the present study as a factor important for evaluation of cardio respiratory fitness.

5. Different macronutrients and micronutrients were included in the present study for assessment the nutritional status as nutrition contributes a lot to the development of obesity.

3.11. Limitation of the study

1. The selected subjects of the present study were limited to Bengali population from three different districts in state of West Bengal, India.

2. This study remains by its cross-sectional intend because of time factors.

3. In the present study, the age range of the subjects was limited to 5 - 12 years.

4. Regarding the analysis of serum lipids profile, only total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides were considered.

5. The study was again limited to the evaluation of coronary artery disease risk factor (CAD) such as obesity marker like serum lipid profile, blood sugar, uric acid, pulse rate and blood pressure. Apart from these other coronary artery disease risk factors were not taken into consideration in the present study.

Anthropometric Obesity Parameters

Chapter IV

4.1. Introduction

Obesity has been described as one of today's most neglected public health problems **(WHO, 2008)**. Obesity is a global epidemic and children are the worst affected with an estimated ten percent of school-aged children being overweight and one quarter of these being obese worldwide **(Dietz & Robinson, 2005).** Childhood obesity epidemic is now penetrating the most developing countries like India, especially in the affluent urban population **(Han et al., 2010)**. The rise in its prevalence among children is a cause of concern, due to its persistence into adulthood and association with morbidity **(Must et al., 1992; Troiano & Flegala, 1998).** Developing countries are facing this "New World Syndrome" accounting to enormous socioeconomic and public health burden (**Bharati et al., 2008)**. Even the accurate measurement of this condition in India is not without quandary.

Central obesity has been associated with the risk of cardiovascular and metabolic disease in children and anthropometric indices predictive of childhood central obesity include waist circumference (WC), waist to hip ratio (WHR) and waist to height ratio (WHtR) **(Freedmann et al., 1999; Kahn & Valdz, 2003; Katzmarzyk et al., 2004; Gower et al., 1999; Kelishadi et al., 2007)**. On the other hand, Body Mass Index, body fat percentage most commonly used as a tool for measuring obesity, with the cut off limits for adults and percentile charts for children **(Cole et al., 1995; Dietz & Bellizzi, 1999; National Center for Health Statistics, 2000)**, is not without limitations.

Though Waist circumference cut off values for Indian adults are being laid, but for assessment of childhood obesity, only percentile charts have been developed for countries like Canada, Cuba, Italy, Spain, United Kingdom and United States by various researchers **(Katzmarzyk, 2004; Martinez et al., 1994; Zannolli et al., 1996; Moreno et al., 1999;**

McCarthy et al., 2001; Fernandez et al., 2004). Even the International Diabetic Federation has recommended the 90^{th} percentile as a limit but without a cut off value **(Zimmet et al., 2007).** On the other hand, waist to thigh ratio (WTR) is able to estimate visceral fat and risk level of diabetes **(Rouriz et al., 2016).** A small thigh circumference has also been implicated as a causal risk factor for multiple diseases**, (Snijder et al., 2003; Heitmann & Frederiksen, 2009; Lu et al., 2010; Li et al., 2010)** and the number of studies investigating thigh circumference as a useful indicator of body fat has increased substantially **(Konstantynowicz et al., 2011; Kuk et al., 2007)**.

Other studies suggest that smaller thighs are disadvantageous to health and survival, and increase diabetes risk among the adult population in both sexes (**Snijder et al., 2003)**. However, in some studies, smaller thighs were related to low muscle mass **(Baron et al., 1988)**. So the, comprehensive worldwide reference values are needed to define central obesity for children. The study was aimed to show the variation of selected anthropometric obesity marker such as body mass index (BMI), body fat percentage, waist circumference (WC), hip circumference (HC), thigh circumference (TC), waist hip ratio (WHR) and waist to thigh ratio (WTR) among three weight categories of 5 to 12 years old age in Bengali school going boys from state of West Bengal, India.

4.2. Materials and methods

The present study was carried out on 1036 selected school going boys between 5 to 12 years of age. The total number of subjects were subdivided into four age groups such as 5 - <7 years, 7 - <9 years, 9 - <11 years and 11 - <13 years and each group was further categories i.e., Normal weight, Overweight and Obese on the basis of BMI-age-boys Z – scores (**WHO, 2007).** Different anthropometric measurements such as height (cm), weight, body mass index BMI (kg/m^2), waist circumference (cm), hip circumference (cm), thigh circumference (cm), waist to hip ratio (WHR), waist to thigh ratio (WTR), and body fat% were measured by standard procedures which have been described elaborately in Chapter III.

4.3. Results

4.3.1. Prevalence of normal weight, overweight and obesity according to age groups of boys (based on age -BMI-boys Z-scores)

Table 4.1 demonstrates that the prevalence of normal weight, overweight and obesity among four different age groups, boys from the age group 5 - < 7 years were 57.95% normal weight, 24.89% overweight and 17.14% obese respectively. Further the study demonstrated that for 7 - < 9 years boys were 55.93% normal weight, 27.58% overweight, 16.47 % obese, for 9 - < 11 years boys were 55.89% normal weight, 23.95 % overweight, 20.15 % obese and for 11 - < 13 years boys were 52.05% normal weight, 30.71 % overweight and 17.22% obese. The overall results indicated that out of 1036 boys studied, the prevalence of overweight and obesity were 26.83 % and 17.16 % respectively.

4.3.2. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weight categories in 5 - < 7 years age group of boys

Table 4.2 shows that the mean height of boys in normal weight category was 113.29 cm (median 113.1 cm, range 106.7 to 120.3 cm), body weight 19.34 kg (median 19.4 kg, range 16.4 to 23.5 kg), BMI 15.03 $kg.m^{-2}$ (median 15.09 $kg.m^{-2}$, range 14 to 16.32 $kg.m^{-2}$), waist circumference 51.09 cm (median 50.8 cm, range 45 to 58 cm), hip circumference 56.23 cm (median 56.2 cm , range 47 to 66.4 cm), thigh circumference 29.45 cm (median 29.4 cm, range 24.5 to 36.5 cm), WHR 0.909 (median 0.911, range 0.744 to 1.006), WTR

1.743 (median 1.739, range 1.434 to 1.966), body fat 12.24% (median 12.33%, range 8.56 to 16.56%).

Table 4.1. Prevalence of normal weight, overweight and obesity in four different age groups of boys (according to age - BMI – boys Z scores)

Age groups (Years	No of Subject	Frequency & Percentage	Normal weight	Overweight	Obese
5 – < 7	245	F	142	61	42
		%	57.95	24.89	17.14
7 – < 9	261	F	146	72	43
		%	55.93	27.58	16.47
9 – < 11	263	F	147	63	53
		%	55.89	23.95	20.15
11 – < 13	267	F	139	82	46
		%	52.05	30.71	17.22
Total	1036	F	574	278	184
		%	55.40	26.83	17.76

The SD values obtained for above mentioned parameters were found to be 4.14 cm for height, 1.84 kg for body weight, and 0.60 $kg.m^{-2}$ for BMI, 3.71 cm for waist circumference, 4.38 cm for hip circumference, 2.38 cm for thigh circumference 0.034 for WHR, 0.096 for WTR and 1.84% for body fat.

On the other hand, mean height of overweight boys was 113.51 cm (median 113.4 cm, range 107.8 to 119.6 cm), body weight 23.01 kg (median 22.8 kg, range 20 to 26 kg), BMI 17.82 $kg.m^{-2}$ (median 17.85 $kg.m^{-2}$, range 16.75 to 18.29 kg.m-^{2}), waist circumference 59.32 cm (median 59.7 cm, range 56.5 to 63.3 cm), hip circumference 60.35 cm (median 60.1 cm, range 56.5 to 66.5 cm), thigh circumference 33.94 cm (median 34 cm, range 29.8 to 37 cm), WHR 0.991 (median 0.996, range 0.902 to 1.041), WTR 1.766 (median 1.747, range 1.605 to 1.986), body fat % 18.16 (median 18.3, range 13.8 to 21.7). The SD values obtained for above mentioned parameters were found to be 3.62 cm for height, 1.79 kg for body weight, and 0.42 kg.m-^{2} for BMI, 1.77 cm for waist circumference , 2.09 cm for hip circumference, 1.38 cm for thigh circumference, 1.013 for WHR, 0.089 WTR, and 2.57 for body fat%.

Table 4.2. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weights categories (Total number of boys = 245, number of normal weight boys = 142, number overweight boys = 61, number of obese boys = 42) under the age group of 5 – < 7 years

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	Height (cm)	113.29	4.14	113.10	106.70	120.30
OW		113.51	3.62	113.40	107.80	119.60
OB		114.15	3.65	115.30	107.80	119.20
NW	Body weight (kg)	19.34	1.84	19.40	16.40	23.50
OW		23.01	1.79	22.80	20.00	26.00
OB		26.43	1.85	26.15	22.60	30.40
NW	BMI (kg.m-^{2})	15.03	0.60	15.09	14.00	16.31
OW		17.82	0.42	17.85	16.75	18.29
OB		20.27	0.90	20.01	18.58	22.29
NW	Waist circumference (cm)	51.09	3.71	50.80	45.00	58.00
OW		59.32	1.77	59.70	56.50	63.30
OB		66.99	2.60	66.50	62.40	71.50
NW	Hip circumference (cm)	56.32	4.38	56.20	47.00	66.40
OW		60.35	2.09	60.10	56.60	66.50
OB		66.37	2.60	66.400	60.50	71.50
NW	Thigh circumference (cm)	29.37	2.38	29.40	24.50	36.50
OW		33.94	1.38	34.00	29.80	37.00
OB		37.16	2.44	36.80	33.00	42.40
NW	WHR	0.909	0.034	0.911	0.744	1.006
OW		0.991	0.024	0.996	0.902	1.041
OB		1.011	0.023	1.013	0.944	1.055
NW	WTR	1.743	0.096	1.739	1.434	1.966
OW		1.766	0.089	1.747	1.605	1.986
OB		1.811	0.103	1.819	1.610	1.992
NW	Body fat%	12.24	1.84	12.33	8.560	16.50
OW		18.16	2.57	18.30	13.80	21.70
OB		21.71	3.60	20.40	18.40	28.50

NW = normal weight; OW = overweight; OB = obese

And, mean height of obese categories was 114.15 cm (median 115.3 cm, range 107.8 to 119.2 cm), body weight 26.43 kg (median 26.15kg, range 22.6 to 30.4 kg), BMI 20.27 kg.m^{-2} (median 17.85 kg.m^{-2}, range 18.58 to 22.29 kg.m^{-2}), waist circumference 66.99 cm (median 66.5 cm, range 62.4 to 71.5 cm), hip circumference 66.37 (median 66.4 cm, range 60.5 to 71.5 cm), thigh circumference 37.16 cm (median 36.8 cm, range 33 to 42.4 cm), WHR 1.011 (median 1.013, range 0.944 to 1.055), WTR 1.811 (median 1.819, range 1.610 to 1.992), body fat % 21.71 (median 20.4%, range 18.4 to 28.5 %). The SD values obtained for above mentioned parameters were found to be 3.65 cm for height, 1.85 kg for body weight, and 0.90 $kg.m^{-2}$ for BMI, 2.60 cm for waist circumference, 2.60 cm for hip circumference, 2.44 cm for thigh circumference, 0.023 for WHR, 0.103 for WTR and 3.60 % for body fat.

4.3.3. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weight categories in 7 – < 9 years age group of boys

Table 4.3 demonstrated that the mean height of boys in normal weight category was 126.00 cm (median127.75 cm, range 119.7 to 131 cm), body weight 24.81 kg (median 24.80 cm, range 21.6 to 28 kg), BMI 15.61 $kg.m^{-2}$ (median $kg.m^{-2}$, 15.62 range 14.28 to 16.89 $kg.m^{-2}$), waist circumference 54.06 cm (median 54.35 cm, range 45.4 to 64 cm), hip circumference 60.78 cm (median 60.85 cm, range 51.6 to 71.2 cm), thigh circumference 32.51 (median 32.50 cm, range 26.8 to 40.5 cm), WHR 0.890 (median 0.890, range 0.809 to 0.953), WTR 1.661 (median 1.655, range 1.318 to 1.904), body fat % 13.40 (median 13.57%, range 10.04 to 16.88%).

The SD values obtained for above mentioned parameters were found to be 2.91 cm for height, 1.62 kg for body weight, and 0.67 $kg.m^{-2}$ for BMI, 3.52 cm for waist circumference, 4.14 cm for hip circumference, 2.87 cm for thigh circumference, 0.029 for WHR, 0.087 for WTR and 1.89 % for body fat.

On the other hand, mean height of overweight boys was 125.87 cm (median 125.50 cm, range 120.4 to 131 cm), body weight 29.22 kg (median 28.80 kg, range 26 to 33 kg), BMI

18.50 kg.m^{-2} (median 18.55 kg.m^{-2}, range 17.21 to 19.37 kg.m^{-2}), waist circumference 64.68 cm (median 64.35 cm, range 59.4 to 70.6 cm), hip circumference 65.64 cm (median 65.50 cm, range 60.9 to 72.3 cm), thigh circumference 37.80 cm (median 37.40 cm, range 33.5 to 44 cm), WHR 0.985 (median 0.986, range 0.913 to 1.028), WTR 1.721 (median 1.696, range 1.479 to 1.973), body fat % 20.09 (median 20.5%, range 16.4 to 23.6).

Table 4.3. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weights categories (Total number of boys = 261, number of normal weight boys = 146, number overweight boys = 72, number of obese boys = 43) under the age group of 7 –< 9 years

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	Height (cm)	126.00	2.91	126.75	119.70	131.00
OW		125.58	2.87	125.50	120.40	131.00
OB		125.87	2.77	126.80	121.40	130.40
NW	Body weight (Kg)	24.81	1.62	24.80	21.60	28.00
OW		29.22	1.98	28.80	26.00	33.00
OB		33.56	2.44	33.80	28.10	37.70
NW	BMI (kg.m-^{2})	15.61	0.67	15.62	14.28	16.89
OW		18.50	0.60	18.55	17.21	19.37
OB		21.16	0.95	21.12	18.49	22.27
NW	Waist circumference (cm)	54.06	3.52	54.35	45.40	64.00
OW		64.68	2.08	64.35	59.40	70.60
OB		73.69	1.62	70.50	73.60	76.60
NW	Hip circumference (cm)	60.78	4.14	60.85	51.60	71.20
OW		65.64	2.36	65.50	60.90	72.30
OB		74.01	2.20	74.4	69.40	78.30
NW	Thigh circumference (cm)	32.51	2.87	32.50	26.80	40.50
OW		37.80	2.58	37.40	33.50	44.00
OB		41.18	2.13	41.20	37.80	45.50
NW	WHR	0.890	0.029	0.890	0.809	0.953
OW		0.985	0.027	0.986	0.913	1.028
OB		0.996	0.022	0.987	0.970	1.053
NW	WTR	1.661	0.087	1.655	1.318	1.904
OW		1.721	0.128	1.696	1.479	1.973
OB		1795	0.091	1.769	1.582	1.980
NW	Body fat%	13.40	1.89	13.57	10.04	16.88
OW		20.09	1.93	20.50	16.40	23.60
OB		24.57	4.32	23.50	18.70	31.50

NW = normal weight; OW = overweight; OB = obese

The SD values obtained for above mentioned parameters were found to be 2.87 cm for height, 1.98 kg for body weight, and 0.60 kg.m^{-2} for BMI, 2.08 cm for waist circumference, 2.36 cm for hip circumference, 2.58 cm for thigh circumference, 0.027 for WHR, 0.128 for WTR and 1.93 % for body fat.

Table 4.3 also shows that the mean height of obese categories was 125.87 cm (median 126.80 cm, range 120.4 to 131 cm), body weight 33.56 kg (median 28.80 kg, range 28.1 to 37.7 kg), BMI 21.16 kg.m^{-2} (median 21.12 kg.m^{-2}, range 18.49 to 22.27 kg.m^{-2}), waist circumference 73.69 cm (median 70.50 cm, range 73.6 to 76.6 cm), hip circumference 74.01 cm (median range 74.4 cm, 69.4 to 78.3 cm), thigh circumference 41.18 (median 41.2 cm, range 37.8 to 45.5 cm), WHR 0.996 (median 0.987, range 0.996 to 0.970 to 1.053), WTR 1.795 (median 1.769, range 1.582 to 1.980), body fat % 24.57 (median 23.5%, range 18.7 to 31.5%). The SD values obtained for above mentioned parameters were found to be 2.77 cm for height, 2.44 kg for body weight, and 0.95 kg.m^{-2} for BMI, 1.62 cm for waist circumference, 2.20 cm for hip circumference, 2.13 cm for thigh circumference, 0.022 for WHR, 0.091 for WTR and 4.32 % for body fat.

4.3.4. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weight categories in 9 - < 11 years age group of boys.

It is evident from the Table 4.4 that the mean height of boys in normal weight category was 135.73 cm (median 135.6 cm, range 130.4 to 142.4 cm), body weight 29.88 kg (median 29.80 kg, range 25.4 to 35 kg), BMI 16.20 kg.m^{-2} (median kg.m^{-2} 16.19, range 14.63 to 17.73 kg.m^{-2}), waist circumference 57.30 cm (median 57.2 cm, range 49.5 to 64 cm), hip circumference 65.89 cm (median 65.5 cm, range 58.2 to 72.8 cm), thigh circumference 35.91 cm (median 35.4 cm, range 29.4 to 41.5 cm), WHR 0.870 (median

0.871, range 0.774 to 0.935), WTR 1.599 (median 1.610, range 1.391 to 1.814), body fat % 13.15 (median 13.11 cm, range 9.32 to 17.45). The SD values obtained for above mentioned parameters were found to be 2.98 cm for height, 2.35 kg for body weight, and 0.90 $kg.m^{-2}$ for BMI, 3.14 cm for waist circumference, 3.64 cm for hip circumference, 2.76 cm for thigh circumference, 0.025 for WHR, 0.076 for WTR and 2.36 % for body fat

On the other hand, the mean height of boys in overweight categories was 136.85 cm (median 137.6, range 130.9 to 142.4 cm), body weight 37.17 kg (median 37.5, range 32.7 to 41.8 kg), BMI 19.83 $kg.m^{-2}$ (median 19.88 $kg.m^{-2}$, range 18.07 to 20.99 $kg.m^{-2}$), waist circumference 69.62 cm (median 69.1 cm, range 64.4 to 73.9 cm), hip circumference 71.94 cm (median 71.4 cm, range 66.3 to 80.2 cm), thigh circumference 42.58 cm (median 43.00 cm, range 36.7 to 47.4 cm), WHR 0.967 (median 0.972 cm, range 0.906 to 1.015), WTR 1.640 (median 1.631, range 1.454 to 1.893), body fat % 21.65 (median 21.53%, range 18.66 to 25.2%). The SD values obtained for above mentioned parameters were found to be 2.86 cm for height, 2.34 kg for body weight, and 0.72 $kg.m^{-2}$ for BMI, 2.88 cm for waist circumference, 2.56 cm for hip circumference, 2.83 cm for thigh circumference, 0.023 for WHR, 0.095 for WTR and 1.79 % for body fat.

In contrast, mean value of height, body weight, BMI, waist circumference, hip circumference, thigh circumference, WHR, WTR and body fat% were found to be 136.51 cm (median 137.4 cm, range 131.7 to 141.6 cm), 43.87 kg (median 44.5 kg, range 36.5 to 50.6 kg), 23.48 $kg.m^{-2}$ (median 23.50 $kg.m^{-2}$, range 20.75 to 25.36), 80.03 cm (median 80.00 cm, range 73.5 to 88.5 cm), 80.79 cm (median 81.00 cm, 73.2 to 90.4 cm), 45.51 cm (median 45.5 cm, range 36.7 to 47.4 cm), 0.990 (median 0.984, range 0.925 to 1.036), 1.768 (median 1.745, range 1.608 to 2.106), 26.46% (median 25.55%, range 22.33 to 34.1) respectively in obese categories. The SD values obtained for above mentioned parameters were found to be 2.98 cm for height, 4.16 kg for body weight, and 1.28 $kg.m^{-2}$

for BMI, 4.01 cm for waist circumference, 3.73 cm for hip circumference, 3.19 cm for thigh circumference, 0.023 for WHR, 0.115 for WTR and 3.54 % for body fat.

Table 4.4. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weight categories (Total number of boys = 263, number of normal weight boys = 147, number overweight boys = 63, number of obese boys = 53) under the age group of 9 – < 11 years

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	Height (cm)	135.73	2.98	135.6	130.4	142.4
OW		136.85	2.86	137.6	130.9	142.1
OB		136.51	2.98	137.4	131.7	141.6
NW	Body weight (Kg)	29.88	2.35	29.8	25.4	35
OW		37.17	2.34	37.5	32.7	41.8
OB		43.87	4.16	44.5	36.5	50.6
NW	BMI (kg.m-^{2})	16.20	0.90	16.19	14.63	17.73
OW		19.83	0.72	19.88	18.07	20.99
OB		23.48	1.28	23.50	20.75	25.36
NW	Waist circumference (cm)	57.30	3.14	57.2	49.5	64
OW		69.62	2.88	69.1	64.4	73.9
OB		80.03	4.01	80	73.5	88.5
NW	Hip circumference (cm)	65.89	3.64	65.5	58.2	72.8
OW		71.94	2.65	71.4	66.3	80.2
OB		80.79	3.73	81	73.2	90.4
NW	Thigh circumference (cm)	35.91	2.76	35.4	29.4	41.5
OW		42.58	2.83	43	36.7	47.4
OB		45.41	3.19	45.5	38.6	51.4
NW	WHR	0.870	0.025	0.871	0.774	0.935
OW		0.967	0.020	0.972	0.906	1.015
OB		0.990	0.023	0.984	0.925	1.036
NW	WTH	1.599	0.076	1.610	1.391	1.814
OW		1.640	0.095	1.631	1.454	1.893
OB		1.768	0.115	1.745	1.608	2.106
NW	Body fat%	13.15	2.36	13.11	9.32	17.45
OW		21.65	1.79	21.53	18.66	25.2
OB		26.46	3.54	25.5	22.33	34.1

NW = normal weight; OW = overweight; OB = obese

4.3.5. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weights categories in 11- < 13 years age group of boys

Table 4.5 demonstrated that the mean height of boys in normal weight boys was 147.65 cm (median 147.5 cm, range 140 to154.5 cm), body weight 36.27 kg (median 36.2 kg, range 31.7 to 44.6 kg), BMI 16.61 kg.m^{-2} (median 16.69 kg.m^{-2}, range 15.30 to 19 kg.m^{-2}), waist circumference 60.1 cm (median 59.4 cm, range 54.4 to 67.6 cm), hip circumference 69.85 cm (median 70.4 cm, range 62.7 to 75.8 cm), thigh circumference 38.84 cm (median 46.55 cm, range 34.2 to 47.2 cm), WHR 0.859 (median 0.956, range 0.775 to 0.928), WTR 1.547 (median 1.664, range 1.302 to 1.474), body fat % 14.13 (median 14.44%, range 10 to 19.9%). The SD values obtained for above mentioned variables were found to be 3.35 cm for height, 3.23 kg for body weight, and 0.87 $kg.m^{-2}$ for BMI, 3.48 cm for waist circumference, 3.54 cm for hip circumference, 3.21 cm for thigh circumference, 0.024 for WHR, 0.082 for WTR and 2.48 % for body fat.

On the other hand, mean values of height, weight, BMI, waist circumference, hip circumference, thigh circumference, WHR, WTR and body fat% were found to be 147.39 cm (median range 147.3 cm, 142.3 to 154.4 cm), 47.49 kg (median 47.00 kg, range 41.7 to 54.5 kg), 21.83 $kg.m^{-2}$ (median 21.97 08 $kg.m^{-2}$, range 19.37 to 23.08 $kg.m^{-2}$), 76.78 cm (median 76.5cm, range 71.4 to 81.4 cm), 80.38 cm (median 80.45 cm, 75.2 to 86 cm), 46.60 cm (median 46.55 cm, range 42.5 to 50.5 cm), 0.954 (median 0.956, range 0.870 to 0.990), 1.547 (median 1.664, range 1.302 to 1.474 cm), 24.97 % (median 24.87%, range 20.43 to 29.78%) respectively in overweight categories.

The SD values obtained for above mentioned parameters were found to be 3.23 cm for height, 3.53 kg for body weight, and 0.87 $kg.m^{-2}$ for BMI, 2.21 cm for waist circumference, 2.51 cm for hip circumference, 1.95 cm for thigh circumference, 0.024 for WHR, 0.059 for WTR and 2.09 % for body fat.

And, mean height of obese boys was 147.47 cm (median 147.3 cm, range 142.5 to 153.5 cm), weight 54.45 kg (median 54.35 kg, range 45.6 to 64 kg), BMI 24.97 $kg.m^{-2}$ (median 1.66 08 $kg.m^{-2}$, range 22.11 to 28.66 $kg.m^{-2}$), waist circumference 88.35 cm (median 88.55 cm, range 80.4 to 95.3 cm), hip circumference 89.98 cm (median 90.1 cm, range

83.4 to 95.2 cm), thigh circumference 50.42 cm (median 50.3 cm, range 45.7 to 56.2 cm), WHR 0.981 (median 0.956, range 0.946 to 1.020), WTR 1.764 (median 1.766, range 1.659 to 1.919), body fat % 28.28 (median 26.79 %, range 22.65 to 37.5 %).

Table 4.5. Mean, standard deviation (SD), median and range of selected anthropometric obesity parameters of three body weight categories (Total number of boys = 267, number of normal weight boys = 139, number of overweight boys = 82, number of obese boys = 46) under the age group of 11 – < 13 years.

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	Height (cm)	147.65	3.35	147.50	140	154.50
OW		147.39	3.23	147.30	142.30	154.40
OB		147.47	3.12	147.30	142.50	153.50
NW	Body weight (Kg)	36.27	2.71	36.20	31.70	44.60
OW		47.49	3.53	47.00	41.70	54.50
OB		54.45	5.63	54.35	45.60	64.00
NW	BMI ($kg.m^{-2}$)	16.61	0.78	16.69	15.30	19.00
OW		21.83	0.87	21.97	19.37	23.08
OB		24.97	1.66	25.04	22.11	28.66
NW	Waist circumference (cm)	60.01	3.48	59.40	54.40	67.60
OW		76.68	2.21	76.50	71.40	81.40
OB		88.35	4.22	88.50	80.40	95.30
NW	Hip circumference (cm)	69.85	3.54	70.40	62.70	75.80
OW		80.38	2.51	80.45	75.20	86.00
OB		89.98	3.24	90.10	83.40	95.20
NW	Thigh circumference (cm)	38.84	3.21	37.90	34.20	47.20
OW		46.60	1.95	46.55	42.50	50.50
OB		50.42	2.24	50.30	45.70	56.20
NW	WHR	0.859	0.025	0.863	0.775	0.928
OW		0.954	0.024	0.956	0.870	0.990
OB		0.981	0.021	0.979	0.946	1.020
NW	WTR	1.547	0.082	1.552	1.302	1.474
OW		1.648	0.059	1.664	1.515	1.793
OB		1.764	0.067	1.766	1.659	1.919
NW	Body fat%	14.13	2.48	14.44	10.23	18.40
OW		24.97	2.09	24.87	20.43	29.78
OB		28.28	4.21	26.79	22.65	37.50

NW = normal weight; OW = overweight; OB = obese

4.3.6. Comparison of selected anthropometric obesity parameters among of three body weight categories of boys in four different age groups

Comparisons of selected anthropometric obesity parameters among three body categories in each of the four age groups of boys are presented in Table 4.6. One way ANOVA was performed to make an overall comparison of the selected anthropometric obesity parameters among three body weight categories in each of the four age groups. Again, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group. It is observed from the Table 4.6 that in 9 - < 11 years age group there no significant difference existed in height among three body weight categories. It is noted from the Table 4.6 that weight, BMI, WC, HC, TC, WHR and body fat% differed significantly ($p<0.01$) among the three weight categories in all age groups. On the other hand, WTR significantly differed ($p<0.01$) among three body weight categories in all age groups except 5 – <7 years, where significant difference only observed between normal weight and obese categories. Moreover, in post hoc multiple comparison tests all pairs of body weight categories in the above mentioned parameters showed significant difference ($p<0.05$) except height where significant ($p<0.05$) difference was only observed in few cases among three body weight categories of boys.

4.3.7. Comparison of selected anthropometric obesity parameters among four age groups in each body weight category of boys

Comparisons of selected anthropometric parameters among four age groups in each of three body weight categories of boys are presented in Fig. 4.1 to 4.7. In Fig. 4.1 comparison of BMI among four age groups in each of Normal weight, Overweight and Obese category has been presented. Fig 4.1 reveals that BMI differed significantly ($p<0.05$) among all age groups in all three body weight categories as observed through one way ANOVA. Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of BMI in every pair of age groups comparison in all three body weight categories. Over all we found that a significant increasing trend of BMI with age in all three body weight categories of boys.

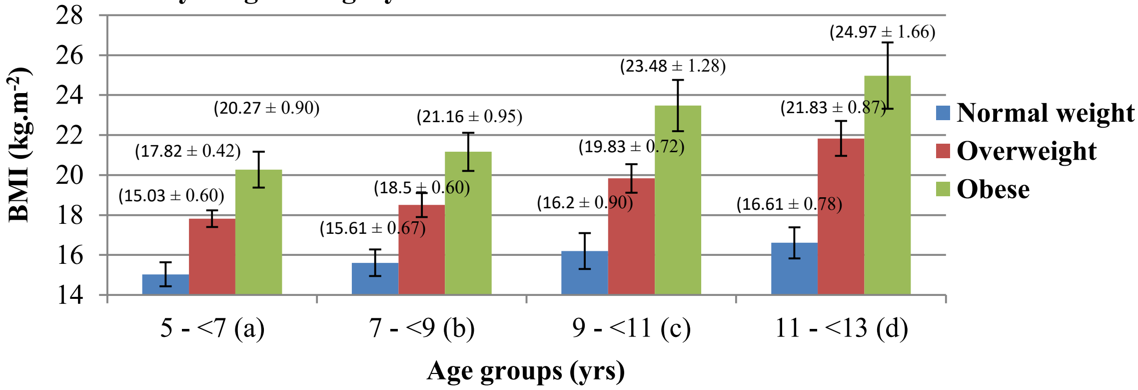
Table 4.6. Comparison of selected anthropometric obesity parameters among three body weight categories in four different age groups of boys

Age groups (yrs)	Category	Height (cm)	Weight (Kg)	BMI (Kg/m^2)	WC (cm)	HC (cm)	TC (cm)	WHR	WHT	Body fat%
5 - < 7 (N = 245)	NW(a) (n =142)	113.29 ± 4.14	19.34 ± 1.84	15.0 ± 0.60	51.09 ± 3.71	56.23 ± 4.37	29.45 ± 2.37	0.909 ± 0.034	1.743 ± 0.096	12.24 ± 1.84
	OW (b) (n = 61)	113.51 ± 3.62	23.01 ± 1.79	17.82 ± 0.42	59.82 ± 1.77	60.35 ± 2.09	33.94 ± 1.38	0.991 ± 0.024	1.766 ± 0.089	18.16 ± 2.57
	OB (c) (n = 42)	114.15 ± 3.65	26.34 ± 1.85	20.27 ± 0.90	66.99 ± 2.60	66.37 ± 2.60	37.16 ± 2.44	1.011 ± 0.023	1.811 ± 0.103	21.71 ± 3.60
F values		0.77	296.59	1282.50	470.17	127.63	224.81	263.28	8.39	304.05
Level of significance		ns	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab(bc)(ac)	** (ac)	**(ab)(bc)(ac)
7 - < 9 (N = 261)	NW (a) (n =146)	126.00 ± 2.91	24.81 ± 1.62	15.61 ± 0.67	54.06 ± 3.52	60.78 ± 4.14	32.51 ± 2.87	0.890 ± 0.029	1.668 ± 0.087	13.40 ± 1.89
	OW (b) (n =72)	125.58 ± 2.87	29.22 ± 1.98	18.50 ± 0.60	64.68 ± 2.08	65.64 ± 2.36	37.80 ± 2.58	0.985 ± 0.027	1.718 ± 0.128	20.09 ± 1.93
	OB (c) (n = 43)	125.87 ± 2.77	33.56 ± 2.44	21.16 ± 0.95	73.69 ±1.62	74.01 ± 2.30	41.18 ± 2.13	0.996 ± 0.022	1794 ± 0.083	24.57 ± 4.32
F values		0.49	403.59	1149.13	857.63	249.55	212.00	419.86	30.47	413.80
Level of significance		ns	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)
9 - < 11 (N = 263)	NW (a) (n =147)	135.73 ± 2.98	29.88 ± 2.35	16.20 ± 0.90	57.30 ± 3.14	65.89 ± 3.64	35.91 ± 2.76	0.870 ± 0.025	1.599 ± 0.076	13.15 ± 2.36
	OW (b) (n = 63)	136.85 ± 2.86	37.17 ± 2.34	19.83 ± 1.28	69.62 ± 2.88	71.94 ± 2.65	42.58 ± 2.83	0.967 ± 0.020	1.640 ± 0.095	21.65 ± 1.79
	Obese(c) (n =53)	136.51 ± 2.98	43.87 ± 4.16	23.48 ± 1.28	80.03 ± 4.01	80.79± 3.73	45.41 ± 3.19	0.990 ± 0.230	1.768 ± 0.115	26.46 ± 3.54
F values		3.65	522.14	1200.05	1022.20	371.23	263.01	670.89	68.16	629.52
Level of significance		*(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	** (ac)(bc)	**(ab)(bc)(ac)
11 -< 13 (N = 267)	NW (a) (n =139)	147.65 ± 3.35	36.27 ± 2.71	16.71 ± 0.78	60.01 ± 3.48	69.85 ± 3.54	38.84 ± 3.21	0.859 ± 0.025	1.547 ± 0.082	14.13 ± 2.48
	OW (b) (n = 82)	147.39 ± 3.23	47.49 ± 3.53	21.83 ± 0.87	76.68 ± 2.21	80.38 ± 2.51	46.60 ± 1.95	0.954 ± 0.024	1.648 ± 0.059	24.97 ± 2.09
	OB (c) (n = 46)	147.47 ± 3.12	54.85 ± 5.63	24.97 ± 1.66	88.35 ± 4.22	89.98 ± 3.24	50.42 ± 2.24	0.981± 0.021	1.764 ± 0.067	28.28 ± 4.21
F values		0.18	532.86	1432.77	1514.12	763.29	403.19	608.72	143.83	655.62
Level of significance		ns	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)

Values are Mean ± SD

'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight category. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected anthropometric obesity parameters among three body weight categories in each age group (* $p < 0.05$, (** $p < 0.01$, ns = not significant). Sceffe's multiple comparisons test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'; BMI = body mass index, WC = waist circumference, HC = hip circumference, TH = thigh circumference, WHR = waist to hip ratio, WTR = waist to thigh ratio, NW = normal weight, OW = overweight, OB = obese

Fig. 4.1. Copmparison of BMI among four age groups in each of three body weight category



Values are mean ± SD

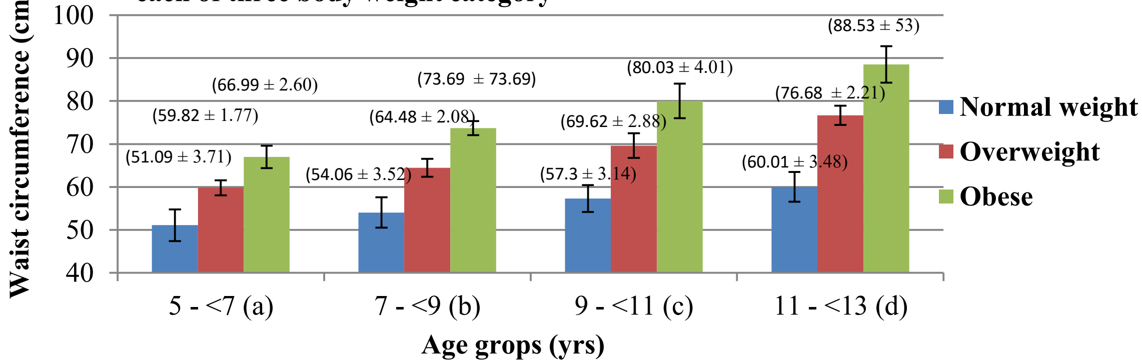
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of BMI among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; BMI = body mass index.

For Normal weight boys, F = 119.94 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 475.39 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Obese boys, F = 130.30 ($p<0.05$); ab, ac, ad, bc, cd, bd

Fig. 4.2. Comparison of waist circumference among four age groups in each of three body weight category



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of waist circumference among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

For Normal weight boys, F = 175.51 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 725.64 ($p<0.05$); ab, ac, ad, bc, cd, bd

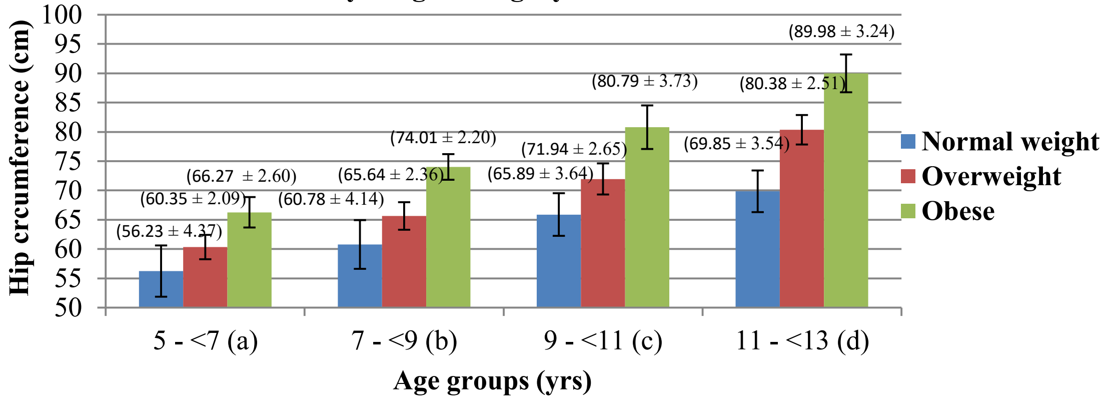
For Obese boys, F = 325.74 ($p<0.05$); ab, ac, ad, bc, cd, bd

In fig. 4.3 comparison of hip circumference comparison among four age groups in each of Normal weight, Overweight and Obese category has been presented. Fig 4.3 shows that hip circumference differed significantly ($p<0.05$) among all age groups in all three body weight categories as observed through one way ANOVA. On the other hand, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of hip circumference in every pair of age groups comparison in all three body weight categories. Overall we found that a significant increasing trend of hip circumference with age in all three body weight categories of boys.

Fig. 4.4 reveals that thigh circumference differed significantly ($p<0.05$) among all age groups in all three body weight categories as observed through one way ANOVA. Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of BMI in every pair of age groups comparison in all three body weight categories. Over all we found that a significant increasing trend of thigh circumference with age in all three body weight categories of boys.

In fig. 4.5 comparison of waist to hip ratio (WHR) among four age groups in each of Normal weight, Overweight and Obese category has been presented. The results of ANOVA showed a significant ($p<0.05$) difference in waist to hip ratio (WHR) among four age groups in normal weight, overweight and obese categories of boys. Moreover, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of waist to hip ratio (WHR) in every pair of age groups comparison in all three body weight categories. Overall we found that a significant decreasing trend of WHR with age in all three body weight categories of boys.

Fig. 4.3. Comparison of hip circumference among four age groups in each of three body weight category



Values are mean ± SD

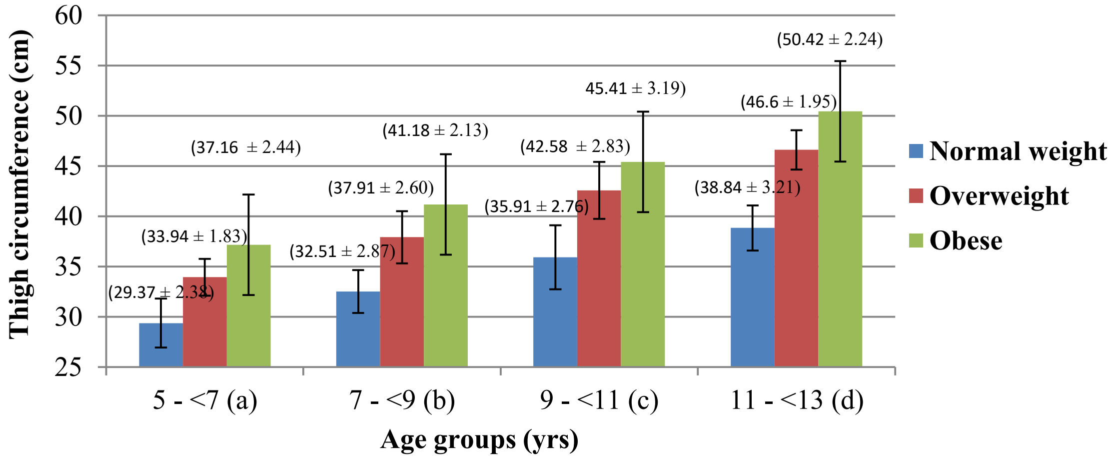
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of hip circumference among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

For Normal weight boys, F = 320.21($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 915 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Obese boys, F = 480.66 ($p<0.05$); ab, ac, ad, bc, cd, bd

Fig. 4.4. Comparison of thigh circumference among four age groups in each of three body weight category



Values are mean ± SD

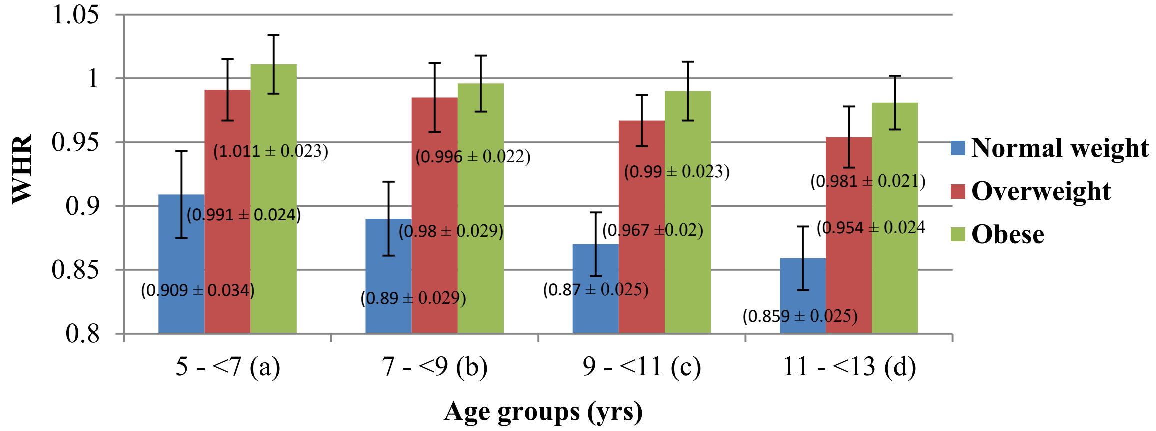
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of thigh circumference among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

For Normal weight boys, F = 298.63 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 393.26 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Obese boys, F = 215.63 ($p<0.05$); ab, ac, ad, bc, cd, bd

Fig. 4.5. Comparison of waist to hip ratio (WHR) among four age groups in each of three body weight category



Values are mean ± SD

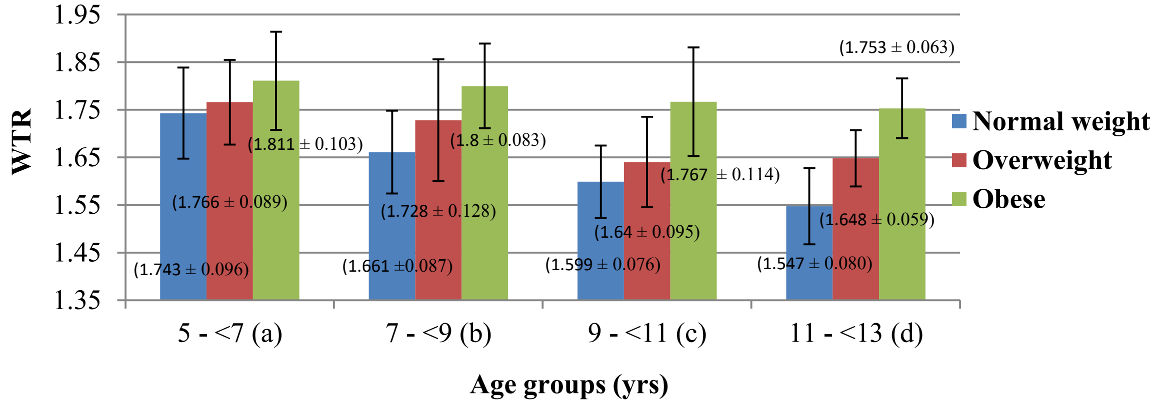
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of WHR among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; WHR = waist to hip ratio.

For Normal weight boys, F = 82.94 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 34.38 ($p<0.05$); ac, ad, bc, bd, cd

For Obese boys, F = 12.98 ($p<0.05$); ab, ac, ad, bd

Fig. 4.6. Comparison of waist to thigh ratio (WTR) among four age groups in each of three body weight category



Values are mean ± SD

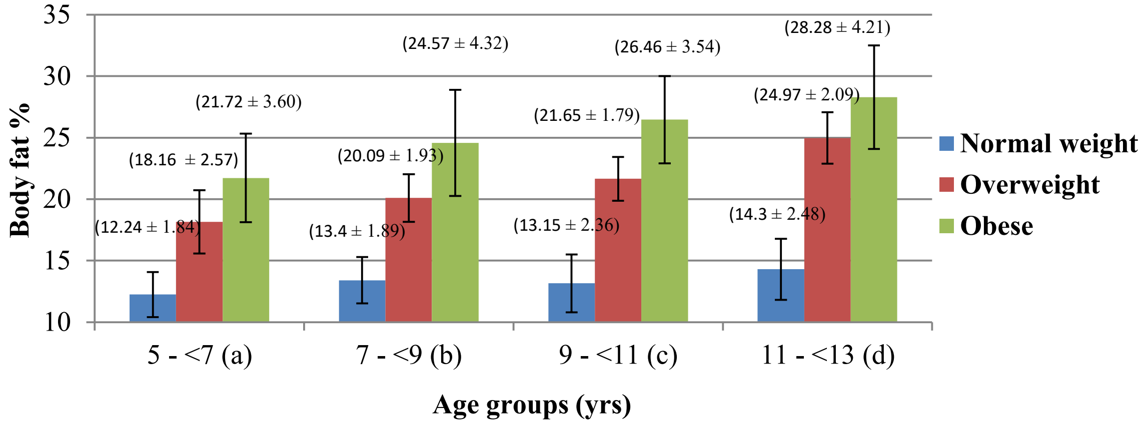
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of WTR among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; WTR = waist to thigh ratio.

For Normal weight boys, F = 134.52 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 26.77 ($p<0.05$); ab, ac, ad, bc, bd

For Obese boys, F = 3.35 ($p<0.05$); ad

Fig. 4.7. Comparison of body fat % among four age groups in each of three body weight category



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of body fat% among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

For Normal weight boys, F = 134.52 ($p<0.05$); ab, ac, ad, bd, cd

For Overweight boys, F = 26.77 ($p<0.05$); ab, ac, ad, bc, bd

For Obese boys, F = 3.35 ($p<0.05$); ab, ac, ad, bd

Comparison of waist to thigh ratio (WTR) among four age groups in each of Normal weight, an Overweight and Obese category has been presented in Fig. 4.6. The results of ANOVA showed a significant ($p<0.05$) difference in waist WTR among four age groups in all three body weight categories of boys. Moreover, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of WTR in every pair of age groups comparison in all three body weight categories of boys except between 5 - < 7 and 7 - < 9 years, 7 - < 9 years and 9 - < 11 years, 9 - < 11 years and 11 - < 13 years in obese boys. Overall we found that a significant decreasing trend of WTR with age in all three body weight categories of boys.

In fig. 4.7 comparison of body fat % among four age groups in each of Normal weight, Overweight and Obese category has been presented. The results of ANOVA showed a significant ($p<0.05$) difference in body fat % among four age groups in normal weight, overweight and obese categories of boys. Moreover, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of body fat % in every pair of age groups comparison in all three body weight categories. Overall we found that a significant increasing trend of body fat % with age in all three body weight categories of boys.

4.3.8. Comparison of percentile values of selected anthropometric obesity parameters among three body weight categories of boys in four different age groups

Comparison of 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentiles of selected anthropometric obesity parameters among three body weight categories of boys in four different age groups are presented in Table 4.7 to 4.13.

It is observed from the Table 4.7 that the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th} and 95^{th} percentile values of body mass index (BMI) were higher in obese categories than that of normal weight categories, and overweight categories in same age groups. On the other hand, all of four percentile values of BMI in overweight weight categories also found to be higher than in normal weight categories in same age groups.

On the other hand, it is evident from the Table 4.8 that all selected percentile values of waist circumference of obese category were higher than that normal weight and overweight categories in identical age group. On the contrary, all the percentile values (the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th} and 95^{th}) of waist circumference were found to be lower in normal weight categories than in overweight categories in same age groups.

The result from the Table 4.9 shows that the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th} and 95^{th} percentile values of hip circumference were higher in obese categories than that of normal weight categories, and overweight categories in identical age groups. On the other hand, all the percentile values (the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th} and 95^{th}) of hip circumference were found to be higher in overweight weight categories than in normal categories in same age groups.

Again it is evident from the Table 4.10 that the lowest (5th) to highest (95th) percentiles of the thigh circumference were lower in normal weight categories than that of overweight and obese categories in same age group. On the other hand all the selected percentile values of thigh circumference were higher in obese categories than of overweight categories in identical age groups. It is also observed from the Table 4.11 that the 5th, 10th, 25th, 75th, 90th and 95th percentile values of WHR were higher in obese categories than that of normal weight categories, and overweight categories in same age groups. In contrast all the percentile values of WHR were found to be higher in overweight weight categories than in normal categories in similar age groups.

4.7. Comparison of selective percentiles values of BMI among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – < 7 N = 245	142	NW	15.03	0.60	14.21	14.25	14.48	15.09	15.47	15.91	16.08
	61	OW	17.82	0.42	16.86	17.22	17.61	17.85	18.19	18.27	18.28
	42	OB	20.27	0.90	18.75	19.23	19.71	20.01	20.90	21.54	21.72
7 – < 9 N = 261	146	NW	15.61	0.67	14.60	14.73	15.03	15.62	16.18	16.51	16.65
	72	OW	18.50	0.60	17.41	17.71	18.01	18.55	18.99	19.28	19.34
	43	OB	21.16	0.95	19.19	19.61	20.49	21.12	21.93	22.20	22.43
9 – < 11 N = 263	147	NW	16.20	0.90	14.88	14.96	15.35	16.19	17.01	17.39	17.61
	63	OW	19.83	0.72	18.71	18.79	19.29	19.88	20.54	20.75	20.90
	53	OB	23.48	1.28	21.04	21.77	22.44	23.50	24.57	25.10	25.23
11 - < 13 N = 267	139	NW	16.61	0.78	15.44	15.62	15.91	16.69	17.19	17.47	18.09
	82	OW	21.83	0.87	20.26	20.69	21.22	21.97	22.53	22.87	22.99
	46	OB	24.97	1.66	22.47	22.72	23.55	25.04	26.11	27.11	27.62

NW = normal weight; OW = overweight; OB = obese

It is noted from the Table 4.12 that lowest (5th) to highest (95th) percentiles values of the WTR were well comparable among three weight categories in same age group. Result from the Table 4.13 shows that the 5th, 10th, 25th, 75th, 90th and 95th percentile values of body fat% percentage higher in obese categories than in normal weight and overweight categories in same age groups. On the contrary, all the percentile values of body fat% were found to be higher in overweight weight categories than in normal categories in identical age groups.

Table 4.8. Comparison of selective percentiles values of waist circumference among three weight body categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – < 7 N = 245	142	NW	51.09	3.71	45.70	46.70	48.00	50.80	54.20	56.60	57.20
	61	OW	59.81	1.78	57.40	57.70	58.10	59.60	61.25	62.45	62.95
	42	OB	66.9	2.60	63.00	63.50	65.00	66.50	70.00	70.50	70.80
7 – < 9 N = 261	146	NW	54.06	3.52	48.60	49.30	51.60	54.35	56.70	58.40	59.40
	72	OW	64.69	2.09	62.30	62.50	63.30	64.30	66.00	67.50	68.60
	43	OB	73.69	1.62	70.80	71.50	72.50	73.60	74.50	75.90	76.50
9 – < 11 N = 263	147	NW	57.30	3.14	52.70	53.40	64.80	57.20	59.40	62.40	62.50
	63	OW	69.69	2.86	65.50	66.00	67.50	69.10	72.80	73.40	73.50
	53	OB	80.03	4.01	74.40	75.00	76.40	80.00	83.40	85.10	85.50
11 - <13 N = 267	139	NW	60.01	3.48	54.80	55.50	57.40	59.40	62.40	65.30	66.40
	82	OW	76.66	2.21	74.30	74.40	74.60	76.50	78.50	79.80	80.50
	46	OB	88.35	4.22	82.30	83.30	84.50	88.50	92.30	93.40	94.40

NW = normal weight; OW = overweight; OB = obese

Table 4.9. Comparison of selective percentiles values of hip circumference among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – < 7 N = 245	142	NW	56.23	4.37	49.30	50.50	52.50	56.20	60.20	62.30	63.20
	61	OW	60.35	2.09	57.70	58.20	59.10	60.10	61.40	63.20	64.30
	42	OB	66.27	2.60	62.00	63.20	64.40	66.40	68.20	69.50	70.30
7 - < 9 N = 261	146	NW	60.78	4.14	54.30	55.00	57.80	60.85	63.60	66.00	67.50
	72	OW	65.64	2.36	62.30	62.90	64.00	65.50	67.05	68.40	70.20
	43	OB	74.01	2.20	70.30	70.50	72.40	74.40	75.50	76.40	77.50
9 - < 11 N = 263	147	NW	65.89	3.64	60.30	61.20	63.40	65.50	68.40	71.20	72.20
	63	OW	71.94	2.65	68.40	69.30	70.00	71.40	74.2	75.20	75.80
	53	OB	80.79	3.73	73.50	76.20	78.00	81.00	83.40	84.70	86.50
11 – < 13 N = 267	139	NW	69.85	3.54	64.40	65.20	67.00	70.40	72.80	74.50	75.30
	82	OW	80.38	2.51	76.30	77.00	78.80	80.45	81.60	83.70	85.00
	46	OB	89.98	3.24	84.20	85.20	87.20	90.10	92.50	94.10	94.60

NW = normal weight; OW = overweight; OB = obese

Table 4.10. Comparison of selective percentiles values of thigh circumference among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 N = 245	142	NW	29.37	2.38	25.90	26.5	27.52	29.45	31.20	32.40	32.70
	61	OW	33.94	1.83	30.50	31.40	32.61	34.40	35.50	36.00	36.42
	42	OB	37.16	2.44	34.40	34.60	35.20	36.80	38.60	40.80	41.50
7 - < 9 N=261	146	NW	32.51	2.87	28.00	28.60	30.10	32.50	34.70	36.40	37.30
	72	OW	37.80	2.58	34.20	34.50	35.65	37.40	40.40	41.20	42.10
	43	OB	41.18	2.13	38.20	38.50	39.50	41.20	42.50	44.60	44.80
9 - < 11 N = 263	147	NW	35.91	2.76	32.0	32.70	34.20	35.40	37.51	40.40	40.70
	63	OW	42.58	2.83	39.90	38.50	39.80	43.00	44.50	46.30	46.80
	53	OB	45.41	3.19	40.30	40.40	43.20	45.50	47.82	49.40	50.50
11- < 13 N = 267	139	NW	38.84	3.21	34.60	34.90	36.20	37.90	41.83	43.11	44.30
	82	OW	46.60	1.95	43.50	44.20	45.20	46.55	47.80	49.50	50.20
	46	OB	50.42	2.24	470	47.80	48.60	50.30	52.20	53.50	54.00

NW = normal weight; OW = overweight; OB = obese

Table 4.11. Comparison of selective percentiles values of WHR among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – < 7 N = 245	142	NW	0.909	0.034	0.852	0.871	0.890	0.911	0.930	0.945	0.963
	61	OW	0.991	0.024	0.951	0.961	0.976	0.996	1.008	1.018	1.023
	42	OB	1.011	0.023	0.978	0.982	0.989	1.013	1.032	1.038	1.040
7 – < 9 N = 261	146	NW	0.890	0.029	0.843	0.853	0.871	0.890	0.908	0.931	0.936
	72	OW	0.985	0.027	0.944	0.974	0.965	0.986	1.012	1.017	1.021
	43	OB	0.996	0.973	0.978	0.975	0.987	1.014	1.014	1.028	1.035
9 - < 11 N=263	147	NW	0.870	0.025	0.829	0.843	0.859	0.871	0.886	0.897	0.903
	63	OW	0.967	0.020	0.933	0.938	0.952	0.972	0.978	0.988	0.990
	53	OB	0.990	0.023	0.960	0.965	0.977	0.984	1.007	1.025	1.031
11 - < 13 N = 267	139	NW	0.859	0.025	0.806	0.823	0.845	0.863	0.876	0.887	0.893
	82	OW	0.954	0.024	0.898	0.923	0.944	0.956	0.973	0.978	0.980
	46	OB	0.981	0.021	0.954	0.955	0.963	0.979	1.005	1.011	1.016

NW = normal weight; OW = overweight; OB = obese

Table 4.12. Comparison of selective percentiles values of WTR among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – < 7 N = 245	142	NW	1.743	0.096	1.588	1.630	1.698	1.739	1.807	1.864	1.901
	61	OW	1.766	0.089	1.667	1.681	1.691	1.747	1.808	1.917	1.936
	42	OB	1.811	0.103	1.616	1.662	1.743	1.819	1.890	1.936	1.951
7 – < 9 N = 261	146	NW	1.668	0.087	1.533	1.551	1.616	1.669	1.731	1.768	1.796
	72	OW	1.728	0.128	1.535	1.555	1.622	1.696	1.822	1.892	1.950
	43	OB	1.794	0.083	1.683	1.703	1.747	1.785	1.854	1.911	1.929
9 - < 11 N = 263	147	NW	1.599	0.076	1.467	1.497	1.553	1.610	1.643	1.677	1.712
	63	OW	1.640	0.095	1.522	1.531	1.559	1.631	1.713	1.770	1.796
	53	OB	1.767	0.114	1.617	1.650	1.679	1.742	1.830	1.930	1.985
11 - < 13 N = 267	139	NW	1.547	0.082	1.404	1.439	1.497	1.552	1.598	1.642	1.678
	82	OW	1.648	0.059	1.560	1.589	1.604	1.644	1.694	1.730	1.752
	46	OB	1.764	0.067	1.663	1.682	1.706	1.766	1.798	1.582	1.884

NW = normal weight; OW = overweight; OB = obese

Table 4.13. Comparison of selective percentiles values of body fat % among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - 7> (N=245)	142	NW	12.24	1.84	9.67	10.25	10.65	12.33	13.55	14.50	15.52
	61	OW	18.61	2.57	14.40	14.80	15.50	18.30	20.40	21.50	21.50
	42	OB	21.71	3.60	18.40	18.50	18.70	20.40	23.50	28.00	28.50
7- 9> (N=261)	146	NW	13.40	1.89	10.55	10.67	11.56	13.57	14.89	15.67	16.33
	72	OW	20.09	1.93	16.80	17.20	18.60	20.50	21.50	22.30	23.30
	43	OB	24.57	4.32	18.90	19.70	20.40	23.50	28.60	31.00	31.40
9-11> (N=263)	147	NW	13.15	2.36	9.81	9.94	10.95	13.11	15.00	16.66	16.89
	63	OW	21.65	1.79	18.96	19.56	20.27	21.53	23.45	24.10	24.41
	53	OB	26.46	3.54	22.45	22.80	23.88	25.50	28.56	32.68	33.89
11-13> (N=267)	139	NW	14.41	2.48	10.45	10.66	11.56	14.44	16.45	17.55	17.67
	82	OW	24.97	2.09	20.97	22.55	23.75	24.87	26.32	27.60	28.93
	46	OB	28.28	4.21	23.98	24.66	24.98	26.79	30.60	36.70	37.20

NW = normal weight; OW = overweight; OB = obese

4.4. Discussion

The present study was based on comparative analysis of selected anthropometric obesity parameters of 5 to 12 years old school going children in three body weight categories, Normal weight, Overweight and obese based on WHO recommendation. The variations of selective anthropometric obesity parameters were also comparable from age to age. Moreover this study was undertaken to estimate the prevalence of overweight and obesity in selected population because overweight and obesity among children is progressing towards epidemic levels. The present study reveals that the overall prevalence of overweight and obesity in the selected boys were 26.83 % and 17.76 %, respectively (Table 4.1). From the results, it has also been noted that prevalence of overweight 30.71 % and obesity 17.22%, were highest in 11 – < 13years age group than in other age groups. This may be due to physiological changes such as hormonal variations taking place with respect to their age resulting in adipose tissue deposition and overall weight gain during the pubertal growth spurt **(Gupta & Ahmed, 1990; Kasmini et al., 1997).**

Most of the studies done in children and adolescents in India have reported prevalence based on national and international cut-off points **(Jagadesan et al., 2014; Khadilkar et al., 2011; Mahshid et al., 2005; Khadikar et al., 2004; Kotian et al., 2010; Sidhu et al., 2006)** with a meta-analysis estimating the prevalence of overweight as 21.5% and obesity as 18.2%. The findings of the present study also corroborate well with the reports of **Mandal & Mandal (2012)**, they reported that the overall prevalence rates of overweight boys were 28.5% among Bengalee school children of West Bengal in India. Studies from different metropolitan cities in India have reported a high prevalence of obesity among affluent school children **(Sundaramet el al., 1988; Bose et al., 2007).**

Present study reveals that mean body mass index, body fat%, waist circumference, hip circumference, thigh circumference, waist to hip ratio and waist to thigh ratio significantly higher in obese boys than in normal weight and overweight boys in same age groups (Table 4.6). On the other hand, all the selected anthropometric obesity parameters were significantly higher in overweight boys than in normal weight boys in same age groups. The higher level of body mass index (BMI) and body fat% may be the cause of less physical activity with intake of high calorie containing food **(WHO, 2002)**.

The present study showed that the mean values of BMI, waist circumference, hip circumference, thigh circumference and body fat% were significantly higher in 11 - < 13 years age group than in others age groups of three body weight categories (Fig. 4.1, 4.2, 4.3, 4.4 & 4.7). Results from the present study also showed that the BMI, waist circumference, hip circumference, and thigh circumference values were increasing with advancement of age. A similar observation was reported by **Bacopoulou et al. (2015**) in Greek adolescent. They showed the mean values of BMI, waist circumference and hip circumference were gradually increasing trend up to 17 years of age. WHR and WTR showed a continuous decrease with advancing age. Consistent with previous literature in **adolescents (Fredriks et al., 2005; McCarthy et al., 2001, Nawarycz et al., 2010, Chiotis et al., 2010; Kuriyan et al., 2011, Brannsether et al., 2011; Haas et al., 2005; Eisenmann et al., 2005)**, waist circumference and body fat% showed an increasing trend with age between 5 to 12 years of old boys.

It is evident from the present study the all the selected percentile values (5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th} and 95^{th}) of the selected anthropometric obesity parameters were higher in obese boys than in normal weight and overweight obese in same age groups (Table 4.7 to 4.13). Moreover, all selected percentile values of anthropometric obesity parameters were higher in overweight boys than in normal weight in same age groups. In our study, 5^{th} to 95^{th}

percentile values of body fat% in all selected age groups were more with another Indian data from Pune city **(Khadikar et al., 2013**). Construction of local reference values to measure adiposity may be much more helpful than using international norm or charts obtained from other population. On the other hand, central obesity marker waist to hip ratio is a generally accepted measure of central obesity that is a traditional risk factor for cardiovascular disease (CVD). For adults population cut-off values for waist circumference were defined between >85 cm and >94 cm for men and between >80 cm and >90 cm for women **(Alberti et al., 2005).** For children and adolescents from different ethnicities no uniform definition of waist circumference (WC) and hip circumference (HC) cut-offs exists because of physiological growth and development. A cross-sectional study by an Italian group **(Maffeis et al., 2001)** found that prepubertal children with a waist circumference >90th percentile were more likely to have multiple risk factors than children with a waist circumference <90th percentile. Their conclusions were based on the relationship between waist circumference with lipid concentrations and blood pressure. The American Bogulesa study (**Moreno et al., 1999)** found similar waist circumference values between 5 to 7 years of age, and somewhat higher values from 8 years onwards to adolescent ages in both American in boys.

4.5. Conclusion

This study has shown that the prevalence of being overweight and obese were 26.83 % and 17.16 % respectively in 5 to 12 years old school going Bengali boys. In addition, BMI, body fat percentage waist circumference, and waist hip ratio (WHR) were important predictors of children becoming overweight and obese, while WTR is less useful for this purpose. Moreover, these findings provide useful information that further strengthens our understanding of the obesity epidemic in children of urban area of West Bengal.

Childhood Obesity & Motor Development

Chapter V

5.1. Introduction

Motor quality may be defined as motor fitness including neuromuscular coordination abilities or motor control bye eye-hand coordination, eye-foot coordination and whole body movement coordination (**Payne & Isaacs, 2005)**. Motor development is classified into two types such as fine and gross motor development. Fine motor development can be defined as development of precise movements that use the small muscles to control small movements of the wrist, hands, hands, fingers, feet, toes, lips, and tongue **(Payne & Isaacs, 2005).** Gross motor development can be defined as development of movements that use the large muscles of the body **(Gallahue & Ozmun, 1998)**, which enables functions such as jumping, running, walking and kicking, and throwing. Early childhood is a critical period to children's development **(Hardy, 2010),** and considered as a period of rapid changes in all areas of child development, such as gross motor skills. During this period, children's abilities develop noticeably and at the end of this period they can use these abilities to achieve their goals (**Shala, 2009).**

Children acquire new gross motor skills most successfully during preschool and elementary school years **(Agnes & Daniel, 2009)**; and are able to master these skills with greater ease during this period than any other point in their life **(Olrich, 2002).** Excess body weight and body fat% in children associated with poorer motor development and gross motor skills performance **(Graf et al., 2004)**. Fine and gross motor skills are basis for almost all physical activities. Proper fine and gross motor development among 5 to 12 years old children is critical and essential. The aim of this study was to understand the influence of anthropometric obesity indices on motor quality development among three body weight categories aged 5 – 12 years in Bengali school going boys.

5.2. Materials and Methods

The present study was carried-out in 1036 healthy school going Bengali boys aged between 5 to 12 years. On the basis of BMI-age-boys Z-scores (normal weight: - 2SD > BMI Z score <+1SD, overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD), boys were categorised in three sub-divisions such Normal weight, Overweight and Obese **(WHO, 2007)**.

All the selected motor quality parameters i.e., hand reaction time (HRT), foot reaction time (FRT), speed of movement (SOM), 30 meter sprint, agility (4 × 10 meter shuttle run), standing long jump (SLJT) and vertical jump test (VJT) were determined by standard procedures which have been elaborately discussed in Chapter III.

5.3. Results

5.3.1 Mean, standard deviation (SD) and range of selected motor quality parameters of three body weight categories in 5 - < 7 years age groups of boys

Table 5.1 shows that the mean HRT of boys in normal weight category was 0.279 sec (range 0.222 to 0.355 sec), FRT 0.360 sec (range 0.326 to 0.393 sec), SOM 0.812 sec (range 0.779 to 0.837 sec), agility 15.08 sec (rang 14.01 to 16.70 sec), 30 meter sprint 7.76 sec (range 7.30 to 8.23 sec), VJT 20.25 cm (range 12.2 to 26.7 cm), SLJ 97.30 cm (range 78.2 to 120.3 cm).

On the other hand, mean HRT of boys in overweight category was 0.320 sec (range 0.242 to 0.390 sec), FRT 0.394 sec (range 0.370 to 0.428 sec), SOM 0.831 sec (range 0.811 to 0.848 sec), agility 16.60 sec (rang 14.84 to 17.65 sec), 30 meter sprint 8.00 sec (range 7.40 to 8.42 sec), VJT 16.09 cm (range 11.4 to 23.4 cm), SLJT 88.13 cm (range 65.6 to 108.4 cm).

In contrast, mean HRT of boys in obese category was 0.346 sec (range 0.273 to 0.418 sec), FRT 0.408 sec (range 0.380 to 0.443 sec), SOM 0.859 sec (range 0.820 to 0.912 sec), agility 18.41 sec (rang 17.67 to 19.2 sec), 30 meter sprint 8.80 sec (range 7.90 to 9.45 sec), VJT 12.79 cm (range 7.9 to 18.5 cm), SLJT 74.08 cm (range 59.6 to 87.7 cm).

Table 5.1. Mean, standard deviation (SD), median and range of selected motor quality parameters of three body weight categories (Total number of boys = 245, number of normal weight boys = 142, number of overweight boys = 61, number of obese boys = 42) under the age group of 5 – < 7 years

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	HRT (sec)	0.279	0.035	0.269	0.222	0.355
OW		0.320	0.049	0.344	0.242	0.390
OB		0.346	0.048	0.345	0.273	0.418
NW	FRT (sec) (right foot)	0.360	0.013	0.358	0.326	0.393
OW		0.394	0.016	0.391	0.370	0.428
OB		0.408	0.020	0.400	0.380	0.443
NW	SOM (sec)	0.812	0.012	0.814	0.779	0.837
OW		0.831	0.009	0.834	0.811	0.848
OB		0.859	0.027	0.850	0.820	0.912
NW	Agility (sec)	15.08	0.670	14.93	14.10	16.70
OW		16.60	0.538	16.65	14.84	17.65
OB		18.41	0.352	17.67	17.67	19.20
NW	30 meter sprint (sec)	7.76	0.234	7.74	7.30	8.23
OW		8.00	0.248	7.95	7.40	8.42
OB		8.80	0.352	8.84	7.90	9.45
NW	VJT (cm)	20.25	3.53	20.15	12.20	26.70
OW		16.09	2.96	16.00	11.40	23.40
OB		12.79	2.76	12.70	7.90	18.50
NW	SLJT (cm)	97.30	9.73	97.70	78.20	120.30
OW		88.13	11.30	86.40	65.60	108.40
OB		74.08	6.78	74.20	59.60	87.70

NW = normal weight; OW = overweight; OB = obese

5.3.2. Mean, standard deviation (SD) and range of selected motor quality parameters of three body weight categories in 7 - < 9 years age groups of boys

Table 5.2 demonstrated that the mean HRT of boys in normal weight category was 0.258 sec (range 0.208 to 0.336 sec), FRT 0.334 sec (range 0.311 to 0.378 sec), SOM 0.786 sec (range 0.732 to 0.832sec), agility 14.10 sec (rang 13.05 to 15.26 sec), 30 meter sprint 6.80

sec (range 6.24 to 7.78 sec), VJT 26.23 cm (range 18.30 to 33.5 cm), SLJT 110.38 cm (range 84.4 to 133.5 cm).

On the other hand, mean HRT of boys in overweight category was 0.299 sec (range 0.224 to 0.375 sec), FRT 0.364 sec (range 0.330 to 0.413 sec), SOM 0.814 sec (range 0.751 to 0.840 sec), agility 15.54 sec (rang 14.35 to 16.51 sec), 30 meter sprint 7.25 sec (range 6.45 to 7.93 sec), VJT 21.04 cm (range 14.4 to 27.4 cm), SLJT 103.52 cm (range 78.1 to 122.5 cm). And, mean HRT of boys in obese category was 0.319 sec (range 0.232 to 0.382 sec), FRT 0.384 sec (range 0.345 to 0.425 sec), SOM 0.839 sec (range 0.816 to 0.874 sec), agility 16.71sec (rang 15.5 to 17.75 sec), 30 meter sprint 8.20 sec (range 7.84 to 8.63 sec), VJT 17.23 cm (range 11.5 to 23.3 cm), SLJT 93.64 cm (range 66.7 to 115.5 cm).

5.3.3. Mean, standard deviation (SD) and range of selected motor quality parameters of three body weight categories in 9 - < 11 years age groups of boys

Table 5.3 shows that the mean HRT of boys in normal category was 0.235 sec (range 0.170 to 0.319 sec), FRT 0.294 sec (range 0.248 to 0.347 sec), SOM 0.734 sec (range 0.652 to 0.794 sec), agility 13.30 sec (rang 12 to 14.31 sec), 30 meter sprint 6.32 sec (range 5.67 to 6.93 sec), VJT 31.74 cm (range 22.5 to 42.3 cm), SLJT 123.69 cm (range 104.4 to 185.5 cm).

On the other hand, mean HRT of boys in overweight category was 0.266 sec (range 0.201 to 0.347 sec), FRT 0.329 (range 0.283 to 0.358 sec), SOM 0.761 sec (range 0.718 to 0.795 sec), agility 14.73 sec (rang 14.24 to 15.27 sec), 30 meter sprint 6.60 sec (range 6.24 to 7.40 sec), VJT 24.85 cm (range 18 to 35.2 cm), SLJT 112.92 cm (range 92.8 to 137.3 cm).

Moreover, mean HRT of boys in obese category was 0.296 sec (range 0.239 to 0.368 sec), FRT 0.346 sec (range 0.298 to 0.385 sec), SOM 0.782 sec (range 0.721 to 0.845 sec), agility 15.80 sec (rang 15.27 to 16.4 sec), 30 meter sprint 7.50 sec (range 6.92 to 8.30 sec), VJT 20.76 cm (range 15.5 to 30.2 cm), SLJT 103.13 cm (range 84 to 129.5 cm).

Table 5.2. Mean, standard deviation (SD), median and range of selected motor quality parameters of three body weight categories (Total number of boys = 261, number of normal weight boys = 146, number overweight boys = 72, obese = 43) under the age group of 7 – < 9 years

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	HRT (sec)	0.258	0.034	0.248	0.208	0.336
OW		0.299	0.050	0.296	0.224	0.375
OB		0.319	0.040	0.320	0.232	0.382
NW	FRT (sec)	0.334	0.013	0.334	0.311	0.378
OW		0.364	0.022	0.359	0.330	0.413
OB		0.384	0.024	0.380	0.345	0.425
NW	SOM (sec)	0.786	0.020	0.788	0.732	0.832
OW		0.814	0.019	0.817	0.751	0.840
OB		0.839	0.015	0.838	0.816	0.874
NW	Agility (sec)	14.10	0.609	14.11	13.05	15.26
OW		15.54	0.615	15.60	14.35	16.51
OB		16.71	0.565	16.71	15.50	17.75
NW	30 meter sprint (sec)	6.80	0.300	6.80	6.24	7.78
OW		7.25	0.308	7.25	6.450	7.93
OB		8.20	0.216	8.18	7.840	8.63
NW	VJT (cm)	26.23	4.20	26.85	18.30	33.50
OW		21.04	3.71	21.30	14.40	27.40
OB		17.23	3.02	16.50	11.50	23.30
NW	SLJ (cm)	110.38	12.07	111.5	84.40	133.50
OW		103.52	11.39	105.50	78.10	122.5
OB		93.64	13.33	94.50	66.70	115.50

NW = normal weight; OW = overweight; OB = obese

5.3.4. Mean standard deviation (SD) and range of selected motor quality parameters of three body weight categories in 11 - < 13 years age groups of boys

Table 5.4 demonstrated that the mean HRT of boys in normal weight category was 0.223 sec (range 0.161 to 0.297 sec), FRT 0.273 sec (range 0.231 to 0.329 sec), SOM 0.630 sec (range 0.563 to 0.691 sec), agility 12.63 sec (rang 12 to 13.41 sec), 30 meter sprint 5.77 sec (range 5.06 to 6.40 sec), VJT 35.71 cm (range 27.2 to 47.3 cm), SLJT 145.30 cm (range 118.3 to 194.4 cm).

On the other hand, mean HRT of boys in overweight category was 0.244 sec (range 0.179 to 0.340 sec), FRT 0.304 (range 0.271 to 0.352 sec), SOM 0.664 sec (range 0.580 to 0.737 sec), agility 14.15 sec (rang 13.27 to 14.89 sec), 30 meter sprint 6.20 sec (range 5.33 to 7.30 sec), VJT 29.38 cm (range 20.5 to 38.2 cm), SLJT 130.27 cm (range 114.6 to 164 cm).

Table 5.3. Mean, standard deviation (SD), median and range of selected motor quality parameters of three body weight categories (Total number of boys = 263, number of normal weight boys = 147, number of overweight boys = 63, number obese boys = 53) under the age group of 9 – <11 years

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	HRT (sec)	0.235	0.037	0.224	0.170	0.319
OW		0.266	0.046	0.255	0.201	0.347
OB		0.296	0.039	0.297	0.239	0.368
NW	FRT (sec)	0.294	0.019	0.296	0.248	0.347
OW		0.329	0.014	0.327	0.283	0.358
OB		0.346	0.018	0.343	0.298	0.385
NW	SOM (sec)	0.734	0.019	0.736	0.652	0.794
OW		0.761	0.014	0.763	0.718	0.795
OB		0.782	0.018	0.780	0.721	0.845
NW	Agility (sec)	13.30	0.558	13.21	12.00	14.31
OW		14.73	0.294	14.70	14.24	15.27
OB		15.80	0.328	15.79	15.27	16.40
NW	30 meter sprint (sec)	6.32	0.209	6.33	5.76	6.93
OW		6.60	0.240	6.58	6.24	7.40
OB		7.50	0.306	7.50	6.92	8.30
NW	VJT (cm)	31.74	5.07	31.20	22.50	42.30
OW		24.85	4.57	24.40	18.00	35.20
OB		20.76	3.75	19.70	15.50	30.20
NW	SLJ (cm)	123.69	12.95	120.40	104.40	158.50
OW		112.92	11.69	111.40	92.80	137.30
OB		103.13	11.76	102.20	84.00	129.50

NW = normal weight; OW = overweight; OB = obese

And, mean HRT of boys in obese category was 0.269 sec (range 0.180 to 0.355 sec), FRT 0.318 sec (range 0.273 to 0.363 sec), SOM 0.684 sec (range 0.586 to 0.750 sec), agility 15.10 sec (rang 14.69 to 15.6 sec), 30 meter sprint 7.42 sec (range 6.70 to 8.40 sec), VJT 25.93 cm (range 19.7 to 33.5 cm), SLJT 119.11 cm (range 102.8 to 142.4 cm).

Table 5.4. Mean, standard deviation (SD), median and range of selected motor quality parameters of three body weight categories (Total number of boys = 267, number of normal weight boys = 139, number overweight boys = 82, number of obese boys = 46) under the age group of 11 - <13 years

Categories	Variables	Mean	SD	Median	Range	
					Minimum	Maximum
NW	HRT (sec)	0.223	0.041	0.216	0.161	0.297
OW		0.244	0.049	0.221	0.179	0.340
OB		0.269	0.063	0.272	0.180	0.355
NW	FRT (sec)	0.273	0.024	0.278	0.231	0.329
OW		0.304	0.020	0.302	0.271	0.352
OB		0.318	0.030	0.327	0.273	0.363
NW	SOM (sec)	0.630	0.028	0.630	0.563	0.691
OW		0.664	0.042	0.659	0.580	0.737
OB		0.684	0.038	0.680	0.586	0.750
NW	Agility (sec)	12.63	0.404	12.65	12.00	13.41
OW		14.15	0.461	14.27	13.27	14.89
OB		15.10	0.240	15.09	14.69	15.60
NW	30 meter sprint (sec)	5.77	0.336	5.76	5.06	6.40
OW		6.20	0.361	6.23	5.33	7.30
OB		7.42	0.393	7.40	6.70	8.40
NW	VJT (cm)	35.71	5.42	35.80	27.20	47.30
OW		29.38	4.01	29.20	20.50	38.20
OB		25.93	4.27	25.25	19.70	33.50
NW	SLJT (cm)	145.30	19.75	1390	118.80	194.40
OW		130.27	10.27	128.20	114.60	164.00
OB		119.11	8.96	117.70	102.80	142.40

NW = normal weight; OW = overweight; OB = obese

5.3.5. Comparison of selected motor quality parameters among three body weight categories of boys in four of age groups

Comparisons of selected motor quality parameters among three body categories in each of the four age groups of boys are presented in Table 5.5. One way ANOVA was performed to make an overall comparison of the selected motor quality parameters among three body weight categories in each of the four age groups. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group. It is observed from the Table 5.5 that hand reaction time (HRT), FRT (foot reaction time), and speed of movement (SOM), agility and 30 meter sprint differed significantly ($p<0.05$) in all age groups.

Table 5.5. Comparison of selected motor quality parameters among three body weight categories in four different age groups of boys

Age groups (yrs)	Categories	HRT (sec)	FRT (sec)	SOM (sec)	Agility (sec)	30 meter Sprint (sec)	VJT (cm)	SLJT (cm)
5 – 7> (N=245)	NW (a) (n =142)	0.279 ± 0.035	0.360 ± 0.013	0.812 ± 0.012	15.08 ± 0.670	7.76 ± 0.234	20.25 ± 3.53	97.3 ± 9.73
	OW (b) (n = 61)	0.320 ± 0.049	0.394 ± 0.016	0.831 ± 0.009	16.60 ± 0.538	8.00 ± 0.248	16.09 ± 2.96	88.13 ± 11.30
	OB (c) (n =42)	0.346 ± 0.048	0.408 ± 0.020	0.859 ± 0.027	18.41 ± 0.532	8.80 ± 0.352	12.79 ± 2.76	74.08 ± 6.78
F values		49.93	210.04	157.25	544.89	253.22	96.53	95.83
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)
7 – 9> (N=261)	NW (a) (n =146)	0.258 ± 0.034	0.334 ± 0.013	0.786 ± 0.020	14.10 ± 0.609	6.80 ± 0.300	26.23 ± 4.20	110.38 ± 12.07
	OW (b) (n =72)	0.299 ± 0.050	0.364 ± 0.022	0.814 ± 0.019	15.54 ± 0.615	7.25 ± 0.308	21.04 ± 3.71	103.52 ± 11.39
	OB (c) (n =43)	0.319 ± 0.040	0.384 ± 0.024	0.839 ± 0.015	16.71 ± 0.565	8.20 ± 0.216	17.23 ± 3.02	93.64 ± 13.33
F values		48.60	148.59	142.25	361.07	393.46	105.25	33.39
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)
9-11> (N=263)	NW (a) (n=147)	0.235 ± 0.037	0.294 ± 0.019	0.734 ± 0.019	13.30 ± 0.558	6.32 ± 0.209	31.74 ± 5.07	123.69 ± 12.95
	OW(b) (n = 63)	0.266 ± 0.046	0.329 ± 0.014	0.761 ± 0.014	14.73 ± 0.294	6.60 ± 0.240	24.85 ± 4.57	112.92 ± 11.69
	OB (c) (n=53)	0.296 ± 0.039	0.346 ± 0.018	0.782 ± 0.018	15.80 ± 0.328	7.50 ± 0.306	20.76 ± 3.75	103.13 ± 11.76
F values		48.78	180.48	69.33	625.85	475.30	122.36	56.64
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)
11-13> (N=267)	NW (a) (n = 139)	0.223 ± 0.041	0.273 ± 0.024	0.630 ± 0.028	12.63 ± 0.404	5.77 ± 0.336	35.71 ± 5.42	145.30 ± 19.75
	OW (b) (n = 82)	0.244 ± 0.049	0.304 ± 0.020	0.664 ± 0.042	14.15 ± 0.461	6.20 ± 0.361	29.38 ± 4.01	130.27 ± 10.27
	OB (c) (n = 46)	0.269 ± 0.063	0.318 ± 0.030	0.684 ± 0.038	15.10 ± 0.240	7.42 ± 0.393	25.93 ± 4.27	119.11 ± 8.96
F values		16.34	77.12	50.26	791.06	373.49	88.93	55.61
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)

Values are Mean ± SD

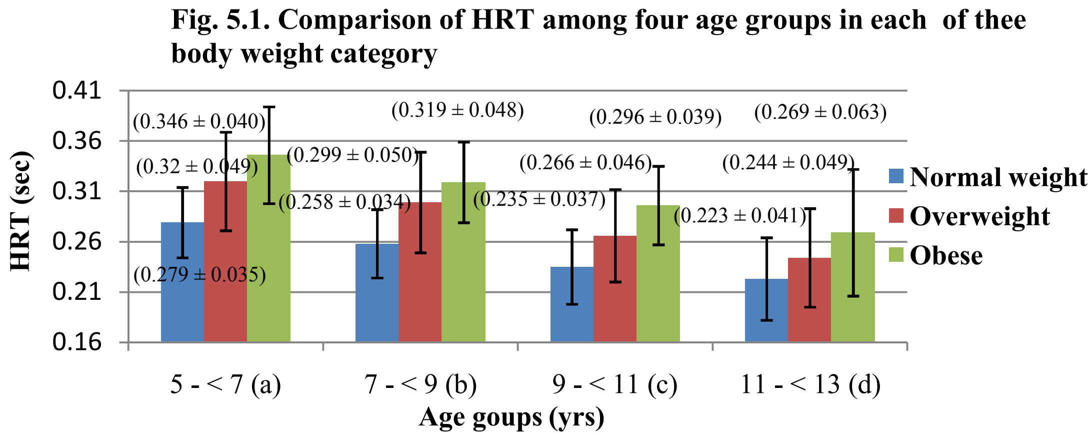
'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight category. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected motor quality parameters among three body weight categories in each age group (* $p < 0.05$, (** $p < 0.01$, ns = not significant). Sceffe's multiple comparisons test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'; HRT = hand reaction time, FRT = foot reaction time, SOM = speed of movement, VJT = vertical jump test, SLJT = standing long jump test, NW = normal weight, OW = overweight, OB = obese

Moreover, in post hoc multiple comparison tests all pairs of body weight categories in the above mentioned parameters showed significant difference ($p<0.05$) among three body weight categories of boys. It is also observed from the Table 5.5 that length related motor quality parameters (i.e., VJT and SLJT) differed significantly ($p<0.01$) among three body weight categories of boys in all age groups.

5.3.6. Comparison of selected motor quality parameters among four age groups in each body weight category of boys

Comparisons of selected motor quality parameters among four age groups in each of three body weight categories of boys are presented in Fig 5.1 to 5.7

In Fig. 5.1 comparison of hand reaction time (HRT) among four age groups in each of Normal weight, Overweight and Obese category has been presented. Fig 5.1 reveals that mean values of HRT differed significantly ($p<0.05$) among all age groups in all three body weight categories as observed through one way ANOVA. Moreover, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of mean values o of HRT in every pair of age groups comparison in all three body weight categories of boys. Overall we found that a significant decreasing trend of HRT with age in all three body weight categories of boys. On the other hand, significance ($p<0.05$) were observed in every pair of groups except between 5 – <7 years and 7 - <9 years, and 5 - <7 years and 9 - <11 years, and 9 - <11 years and 11 - <13 years in overweight boys and between 5 - <7 years and 9 - <11 years, and 5 - < 7 and 9 - <11, 7 – <9 years and 11 - <13 years of obese boys. Comparison of foot reaction time (FRT) among four age groups in each of Normal weight, Overweight and Obese category has been presented in Fig. 5.2. The results of ANOVA showed a significant difference ($p<0.05$) of foot reaction time (FRT) among all four age groups in all three body weight categories of boys.



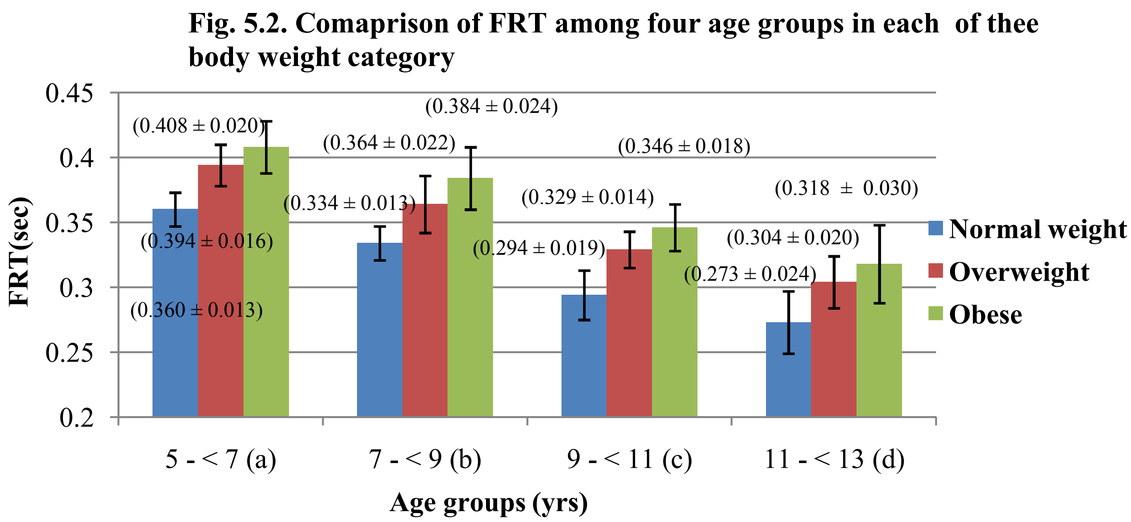
Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of HRT among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; HRT = hand reaction time

For Normal weight boys, F = 61.39 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Overweight boys, F = 33.16 ($p<0.05$); ac, ad, bc, bd

For Obese boys, F = 19.66 ($p<0.05$); ac, ad, bd



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of FRT among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; FRT = foot reaction time

For Normal weight boys, F = 653.21 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Overweight boys, F = 296.46 ($p<0.05$); ab, ac, ad, bc, bd, cd

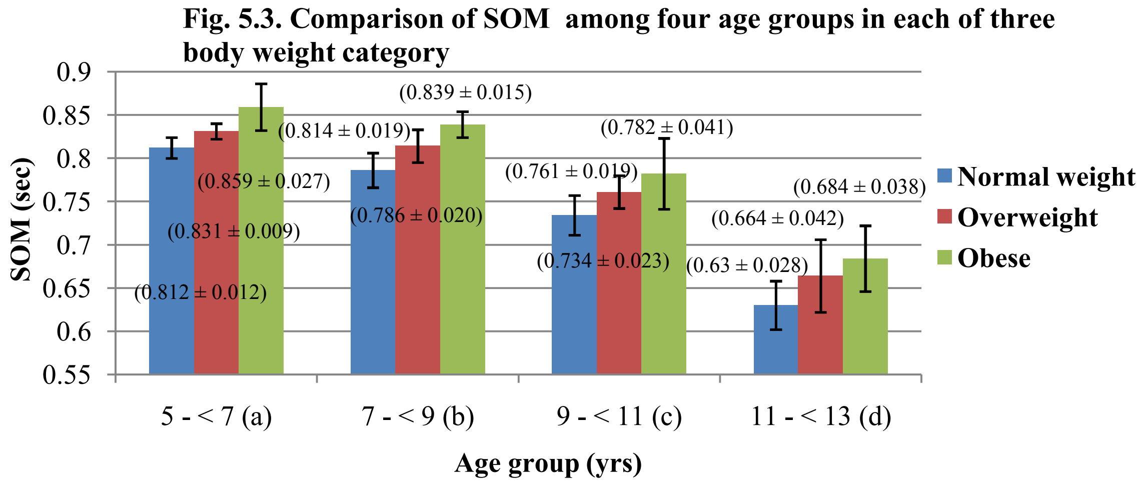
For Obese boys, F = 127.20 ($p<0.05$); ab, ac, ad, bc, bd, cd

Moreover, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of mean values of FRT in every pair of age groups comparison in all three body weight categories of boys. Overall we found that a significant decreasing trend of FRT with age in all three body weight categories of boys.

In Fig. 5.3 comparison of speed of movement (SOM) among four age groups in each of Normal weight, Overweight and Obese category has been presented. Fig 5.3 reveals that mean values SOM differed significantly ($p<0.05$) among all age groups in all three body weight categories as observed through one way ANOVA. Moreover, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of mean values of SOM in every pair of age groups comparison in all three body weight categories of boys. Overall we found that a significant decreasing trend of time of SOM with age in all three body weight categories of boys.

Comparison of agility among four age groups in each of Normal weight, Overweight and Obese category has been presented in Fig. 5.4. The results of ANOVA showed a significant difference ($p<0.05$) of mean values of agility among all four age groups in all three body weight categories of boys. Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of mean values of agility in every pair of age groups comparison in all three body weight categories of boys. Overall we found that a significant decreasing trend of time of agility with age in all three body weight categories of boys.

In Fig. 5.5 comparison of 30 meter sprint among four age groups in each of Normal weight, Overweight and Obese category has been presented. Fig 5.5 reveals that mean values of 30 meter sprint differed significantly ($p<0.05$) among all age groups in all three body weight categories as observed through one way ANOVA.



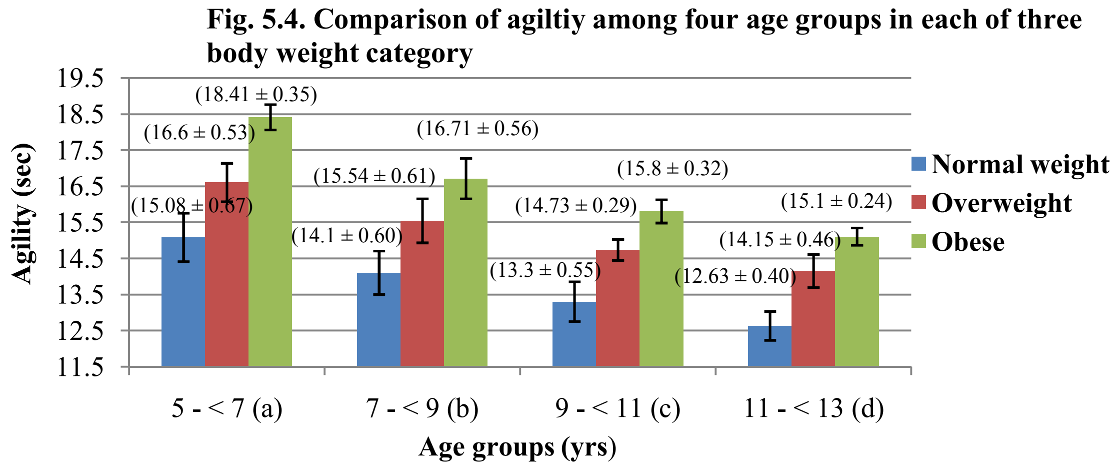
Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of SOM among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; SOM = speed of movement

For Normal weight boys, F = 1861 ($p<0.01$); ab, ac, ad, bc, bd cd

For Overweight boys, F = 585 ($p<0.05$); ab, ac, ad, bc, bd cd

For Obese boys, F = 252.17 ($p<0.05$); ac, ad, bc, bd



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of agility among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

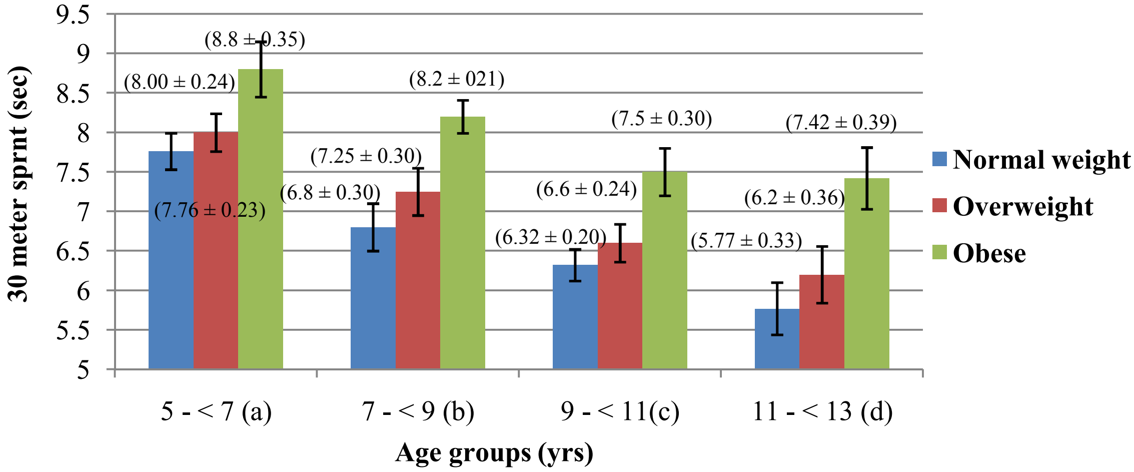
For Normal weight boys, F = 484.54 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Overweight boys, F = 316.54 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Obese boys, F = 608.43 ($p<0.05$); ab, ac, ad, bc, bd, cd

Moreover, Schefee's multiple comparison tests also demonstrated that significant (p<0.05) difference of 30 meter sprint in every pair of age groups comparison in all three body weight categories of boys. Overall we found that a significant decreasing trend of time of 30 meter sprint with age in all three body weight categories of boys.

Fig.5.5. Comparison of 30 meter sprint among four age groups in each of three body weight category



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of 30 meter sprint among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

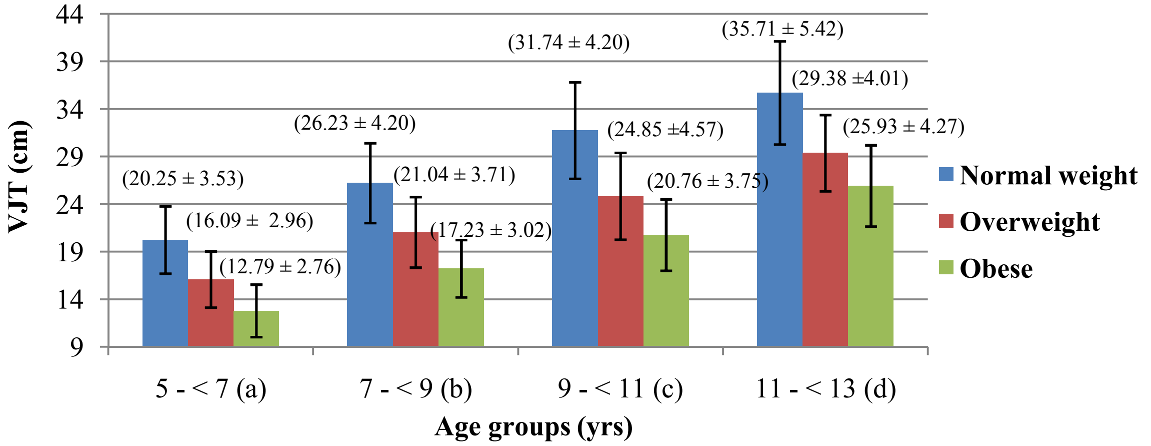
For Normal weight boys, F = 1338 (p<0.01); ab, ac, ad, bc, bd,cd

For Overweight boys, F = 477.55 (p<0.05); ab, ac, ad, bc, bd,cd

For Obese boys, F = 179.17 (p<0.05); ac, ad, bc, bd

In Fig. 5.6 comparison of vertical jump test (VJT) among four age groups in each of Normal weight, Overweight and Obese category has been presented. Fig 5.6 reveals that mean values of 30 meter sprint differed significantly (p<0.05) among all age groups in all three body weight categories as observed through one way ANOVA.

Fig. 5.6. Comparison of VJT among four age groups in each of three body weight category



Values are mean ± SD

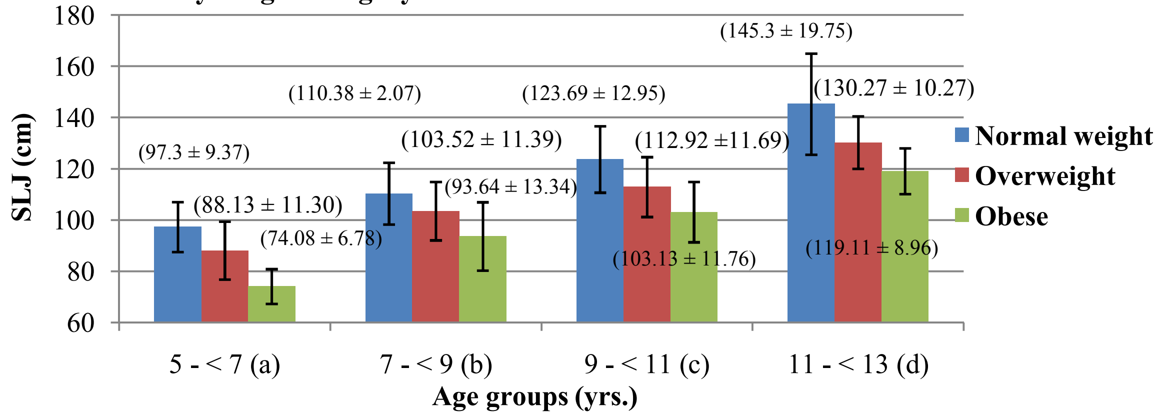
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of VJT among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; VJT = Vertical jump test

For Normal weight boys, F = 299.80 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Overweight boys, F = 149.40 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Obese boys, F = 108.97 ($p<0.05$); ab, ac, ad, bc, bd, cd

Fig.5.7. Comparison of SLJT among four age groups in each of three body weight category



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of SLJT among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; SLJT = standing long jump

For Normal weight boys, F = 298.71 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Overweight boys, F = 178.8 ($p<0.05$); ab, ac, ad, bc, bd, cd

For Obese boys, F = 138.97 ($p<0.05$); ab, ac, ad, bc, bd, cd

Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of mean values of VJT in every pair of age groups comparison in all three body weight categories of boys. Overall we found that a significant increasing trend of VJT values with age in all three body weight categories of boys.

In Fig. 5.7 comparison of standing long jump test (SLJT) among four age groups in each of Normal weight, Overweight and Obese category has been presented. Fig 5.1 reveals that mean values of SLJT differed significantly ($p<0.05$) among all age groups in all three body weight categories as observed through one way ANOVA. Moreover, Schefee's multiple comparison tests also demonstrated that significant ($p<0.05$) difference of mean values SLJT in every pair of age groups comparison in all three body weight categories of boys. Overall we found that a significant increasing trend of SLJT values with age in all three body weight categories of boys.

5.3.7. Comparison of percentile values of selected motor quality parameters among three body weight categories of boys in four different age groups

Comparison of 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles of selected motor quality parameters among three body weight categories in four different age groups are presented in Table 5.6 to 5.12.

It is observed from the Table 5.6 that the 5th, 10th, 25th, 75th, 90th and 95th percentile values of hand reaction time (HRT) were higher in obese categories than that of normal weight categories, and overweight categories in same age groups. On the other hand, all of four percentile values of HRT in overweight weight categories also found to be higher than in normal weight categories in same age groups.

On the other hand, it is evident from the Table 5.7 that all selected percentile values of foot reaction time (FRT) of obese category were higher than in normal weight and overweight categories in same age group. On the contrary, all the selected percentile values (i.e., 5th, 10th, 25th, 75th, 90th and 95th) of FRT were found to be lower in normal weight categories than in overweight categories in identical age groups.

The result from the Table 5.8 shows that the 5th, 10th, 25th, 75th, 90th and 95th percentile values speed of movement (SOM) were higher in obese categories than that of normal weight categories, and overweight categories in same age groups. In contrast, all the percentile values (the 5th, 10th, 25th, 75th, 90th and 95th) of SOM were found to be higher in overweight weight categories than in normal categories in identical age groups.

The result from the Table 5.9 shows that the lowest 5th to highest 95th percentile values of agility were higher in obese categories than in normal weight categories, and overweight categories in identical age groups. On the other hand, all the percentile values of (i.e., 5th to 95th) of agility were found to be higher in overweight weight categories than in normal categories in same age groups.

Again it is evident from the Table 5.10 that the lowest (5th) to highest (95th) percentiles of 30 meter sprint were lower in normal weight categories than in overweight and obese categories in same age group. On the other hand all the selected percentile values of 30 meter sprint were higher in obese categories than of overweight categories in identical age groups. It is also observed from the Table 5.11 that the 5th, 10th, 25th, 75th, 90th and 95th percentile values of VJT were lower in obese categories than in normal weight categories, and overweight categories in same age groups. In contrast all the percentile values VJT were found to be lower in overweight weight categories than in normal categories in same age groups.

5.6. Comparison of selective percentiles values of HRT (sec) among three body weight categories of four different age groups

Age group (years)	F	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - 7 > (N = 245)	142	NW	0.279	0.035	0.232	0.336	0.249	0.269	0.311	0.331	0.339
	61	OW	0.320	0.049	0.255	0.262	0.272	0.344	0.365	0.383	0.388
	42	OB	0.346	0.048	0.285	0.289	0.298	0.345	0.388	0.412	0.415
7 - 9 > (N = 261)	146	NW	0.258	0.347	0.217	0.220	0.032	0.248	0.279	0.317	0.327
	72	OW	0.299	0.050	0.230	0.233	0.249	0.296	0.347	0.361	0.368
	43	OB	0.319	0.040	0.242	0.273	0.292	0.320	0.349	0.375	0.380
9 - 11> (N = 263)	147	NW	0.235	0.037	0.188	0.194	0.210	0.224	0.255	0.298	0.312
	63	OW	0.266	0.046	0.211	0.217	0.225	0.255	0.310	0.335	0.340
	53	OB	0.296	0.039	0.243	0.245	0.258	0.297	0.333	0.356	0.362
11 - 13> (N = 267)	139	NW	0.223	0.041	0.167	0.172	0.186	0.216	0.265	0.287	0.290
	82	OW	0.244	0.049	0.188	0.190	0.206	0.221	0.296	0.321	0.328
	46	OB	0.269	0.063	0.185	0.186	0.210	0.272	0.326	0.350	0.354

NW = normal weight; OW = overweight; OB = obese; F = frequency

5.7. Comparison of selective percentiles values of FRT (sec) among three body weight categories of four different age groups

Age group (years)	F	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – 7 > (N = 245)	142	NW	0.360	0.013	0.342	0.344	0.350	0.358	0.371	0.378	0.384
	61	OW	0.394	0.016	0.373	0.375	0.382	0.391	0.411	0.419	0.424
	42	OB	0.408	0.020	0.385	0.386	0.392	0.400	0.426	0.440	0.442
7 – 9 > (N = 261)	146	NW	0.334	0.013	0.315	0.317	0.324	0.334	0.344	0.353	0.358
	72	OW	0.364	0.022	0.337	0.340	0.345	0.359	0.379	0.402	0.406
	43	OB	0.364	0.024	0.348	0.352	0.365	0.380	0.407	0418	0.423
9-11 > (N = 263)	147	NW	0.294	0.019	0.259	0.265	0.282	0.296	0.311	0.320	0.324
	63	OW	0.329	0.014	0.311	0.314	0.319	0.327	0.339	0.349	0.352
	53	OB	0.346	0.018	0.320	0.327	0.334	0.343	0.357	0.372	0.375
11 – 13 > (N = 267)	139	NW	0.273	0.024	0.235	0.239	0.249	0.278	0.294	0.302	0.306
	82	OW	0.304	0.020	0.273	0.277	0.288	0.302	0.322	0.331	0.339
	46	OB	0.323	0.030	0.274	0.275	0.282	0.327	0.344	0.357	0.362

NW = normal weight; OW = overweight; OB = obese; F = frequency

The result from the Table 5.12 shows that the lowest 5^{th} to highest 95^{th} percentile values of standing long jump test (SLJT) were lower in obese categories than in normal weight categories, and overweight categories in identical age groups. In contrast, all the percentile values of (i.e., 5^{th} to 95^{th}) of SLJT were found to be higher in overweight weight categories than in normal categories in same age groups.

5.8. Comparison of selective percentiles values of SOM (sec) among three body weight categories of four different age groups

Age group (years)	F	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – 7 > (N = 245)	142	NW	0.812	0.012	0.791	0.795	0.806	0.814	0.821	0.827	0.832
	61	OW	0.831	0.009	0.817	0.818	0.824	0.833	0.838	0.842	0.845
	42	OB	0.859	0.027	0.825	0.830	0.837	0.850	0.884	0.895	0.907
7 - 9 > (N=261)	146	NW	0.786	0.020	0.753	0.758	0.771	0.788	0.803	0.812	0.818
	72	OW	0.814	0.019	0.764	0.791	0.808	0.817	0.828	0.832	0.837
	43	OB	0.839	0.015	0.818	0.820	0.828	0.838	0.853	0.861	0.866
9 - 11> (N = 263)	147	NW	0.734	0.023	0.693	0.709	0.721	0.736	0.750	0.763	0.766
	63	OW	0.761	0.019	0.728	0.736	0.748	0.763	0.772	0.787	0.792
	53	OB	0.782	0.041	0.724	0.728	0.740	0.780	0.821	0.833	0.841
11 - 13> (N = 267)	139	NW	0.630	0.028	0.583	0.583	0.610	0.630	0.652	0.672	0.676
	82	OW	0.664	0.042	0.594	0.616	0.633	0.659	0.708	0.720	0.725
	46	OB	0.684	0.038	0.625	0.635	0.667	0.680	0.717	0.734	0.748

NW = normal weight; OW = overweight; OB = obese; F = frequency

5.9. Comparison of selective percentiles values of agility (sec) among three body weight categories of four different age groups

Age group (years)	F	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – 7 > (N = 245)	142	NW	15.08	0.67	14.18	14.33	14.55	14.93	15.54	16.15	16.30
	61	OW	16.60	0.53	15.77	15.98	16.28	16.65	16.93	17.31	17.40
	42	OB	18.40	0.35	17.88	19.74	18.16	18.46	18.67	18.79	18.85
7 – 9 > (N = 261)	146	NW	14.10	0.60	13.17	13.27	13.62	14.11	14.55	15.00	15.14
	72	OW	15.54	0.61	14.48	14.55	15.13	15.60	16.10	16.29	16.34
	43	OB	16.71	0.56	15.84	16.03	16.29	16.71	17.19	17.55	17.58
9 – 11 > (N = 263)	147	NW	13.30	0.55	12.51	12.60	12.83	13.21	13.77	14.13	14.22
	63	OW	14.73	0.29	14.29	14.35	14.50	14.70	14.98	15.16	15.20
	53	OB	15.80	0.32	15.29	15.35	15.54	15.79	16.09	16.25	16.31
11 – 13 > (N = 267)	139	NW	12.63	0.40	12.07	12.11	12.22	12.65	12.98	13.19	13.30
	82	OW	14.15	0.46	13.36	13.47	13.76	14.27	14.52	14.72	14.80
	46	OB	15.10	0.24	14.77	14.80	14.90	15.09	15.27	15.48	15.51

NW = normal weight; OW = overweight; OB = obese; F = frequency

5.10. Comparison of selective percentiles values of 30 meter sprint (sec) among three body weight categories of four different age groups

Age group (years)	F	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 -7 > (N = 245)	142	NW	7.76	0.23	7.39	7.46	7.59	7.74	7.94	8.10	8.13
	61	OW	8.00	0.24	7.66	7.68	7.84	7.95	8.26	8.33	8.36
	42	OB	8.80	0.35	8.34	8.40	8.50	8.84	9.05	9.22	9.40
7 – 9 > (N = 261)	146	NW	6.80	0.30	6.33	6.41	6.57	6.80	7.01	7.21	7.28
	72	OW	7.25	0.30	6.77	6.88	7.04	7.25	7.50	7.64	7.77
	43	OB	8.63	0.21	7.89	7.91	8.04	8.18	8.34	8.50	8.53
9 -11 > (N =263)	147	NW	6.32	0.20	5.90	6.07	6.20	6.33	6.44	6.60	6.68
	63	OW	6.60	0.24	6.31	6.34	6.40	6.58	6.74	6.90	7.05
	53	OB	7.50	0.30	7.08	7.14	7.28	7.50	7.70	7.90	8.08
11-13 > (N = 267)	139	NW	5.77	0.33	5.21	5.31	5.50	5.76	6.09	6.22	6.30
	82	OW	6.20	0.36	5.62	5.66	5.98	6.23	6.41	6.63	6.70
	46	OB	7.42	0.39	6.79	6.92	7.17	7.40	7.68	7.90	8.10

NW = normal weight; OW = overweight; OB = obese; F = frequency

5.11. Comparison of selective percentiles values of VJT (cm) among three body weight categories of four different age groups

Age group (years)	F	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – 7 > (N = 245)	142	NW	20.25	3.53	14.70	15.70	17.40	20.15	23.3	25.20	25.80
	61	OW	16.09	2.96	11.80	12.50	13.70	16.00	18.00	20.50	21.20
	42	OB	12.79	2.76	8.80	9.40	10.40	12.70	14.50	16.50	17.30
7 – 9 > (N = 261)	146	NW	26.23	4.20	19.40	20.40	22.60	26.85	29.30	31.70	32.80
	72	OW	21.04	3.71	15.30	16.40	17.55	21.30	24.25	25.90	26.70
	43	OB	17.23	3.02	12.80	13.60	14.70	16.50	19.80	21.50	21.70
9 - 11 > (N = 263)	147	NW	31.74	5.07	23.80	25.50	27.50	31.20	35.60	39.00	40.50
	63	OW	24.85	4.57	18.50	19.30	21.40	24.40	28.30	31.20	33.70
	53	OB	20.76	3.75	16.40	17.00	17.80	19.70	22.30	27.10	29.40
11 – 13 > (N = 267)	139	NW	35.71	5.42	27.90	29.00	30.50	35.80	39.90	43.20	44.80
	82	OW	29.38	4.01	23.80	24.40	26.40	29.20	31.50	35.50	36.10
	46	OB	25.93	4.27	20.20	20.60	22.60	25.25	30.50	32.00	32.60

NW = normal weight; OW = overweight; OB = obese; F = frequency

5.12. Comparison of selective percentiles values of SLJT (cm) among three body weight categories of four different age groups

Age group (years)	F	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - 7 > (N = 245)	142	NW	97.30	9.73	82	84.3	88.9	97.7	103.6	110.4	114.4
	61	OW	88.13	11.30	73.6	74.8	79.9	86.4	97.4	104.7	105.5
	42	OB	74.08	6.78	63.4	65.5	68.8	74.2	80.0	81.5	82.3
7 - 9 > (N = 261)	146	NW	110.38	12.07	88.5	94.4	100.4	111.5	120.2	124.4	129.0
	72	OW	103.52	11.39	79.2	87.8	94.75	105.5	112.4	116.4	119.4
	43	OB	93.64	13.33	73.7	76.6	82.6	94.5	105.9	110.2	111.6
9 - 11 > (N = 263)	147	NW	123.69	12.95	108.4	109.3	113.4	120.4	133.5	143.0	147.7
	63	OW	112.9	11.69	95.5	98.3	104.6	111.4	119.6	132.4	135.0
	53	OB	103.13	11.76	86.7	88.7	94.3	102.2	112.5	118.2	126.5
11 - 13 > (N = 267)	139	NW	145.30	19.75	123.3	124.7	129.2	139.0	156.2	178.9	186.5
	82	OW	130.27	10.27	116.7	118	122.6	128.2	136.5	144.7	149.5
	46	OB	119.11	8.96	107.4	107.8	112.7	117.7	124.3	131.9	137.1

5.3.8. Determination of association of age with selected motor quality parameters

Pearson's product-moment correlation coefficients of age with selected motor quality parameters were presented in Table 5.13.

Correlation analysis demonstrated that age had significant and negative correlation (p<0.001) with fine motor skill (i.e., HRT, FRT, SOM). Result also showed that age had significant (p<0.001> and negative correlation (p<0.001) with time related gross motor skill (i.e., agility and sprint). On the other hand, result from the Table 5.14 showed that age had significant positive correlation (p<0.001) with length related gross motor skill (i.e., VJT and SLJT).

5.3.9. Determination of association of BMI and body fat% with selected motor quality parameters

Pearson product-moment correlation coefficients of BMI and body fat% with selected motor quality parameters are presented in Table 5.14. It is evident from the Table 5.15 that BMI and body fat% had significant and positive correlation with time related motor quality parameters (i.e., HRT, FRT, agility and sprint). It is also evident from the Table 5.14 that BMI and body fat% had significant and negative correlation with length related gross motor quality parameters (i.e., VJT and SLJT).

5.13. Pearson's Product-moment correlation coefficient of age with selected motor quality parameters

Variables	Age (Years) (N = 1036)		
	r	95% CI	Level of significance
HRT(sec)	-0.432	-0.481 to -0.760	p< 0.001
FRT(sec)	-0.760	-0.784 to -0.733	p< 0.001
SOM(sec)	-0.862	-0.877 to -0845	p< 0.001
Agility(sec)	-0.602	-0.645 to -0.568	p< 0.001
30 meter sprint(sec)	-0.748	-0.744 to -0.720	p< 0.001
VJT(cm)	0.675	0.640 to 0.707	p< 0.001
SLJ (cm)	0.730	0.700 to 0.757	p< 0.001
ns = not significant, 95 % CI = 95% confidence intervals			

HRT = hand reaction time; FRT = foot reaction time; SOM = speed of movement; VJT = vertical Jump test; SLJT = standing long jump test

5.14. Pearson's Product-moment correlation coefficient of BMI and body fat% with selected motor quality parameters

Variables	BMI(kg/m^2) (N = 1036)			Body fat% (N = 1036)		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
HRT(sec)	0.286	0.229 to 0.341	p< 0.001	0.396	0.342 to 0.448	p< 0.001
FRT(sec)	0.136	0.076 to 0.195	p< 0.05	0.247	0.188 to 0.303	p< 0.01
SOM(sec)	0.018	- 0.047 to 0.09	ns	0.016	- 0.044 to 0.07	ns
Agility(sec)	0.365	0.311 to 0.416	p< 0.001	0.398	0.340 to 0.443	p< 0.001
30 MS (sec)	0.179	0.120 to 0.238	p< 0.05	0.218	0.160 to 0.276	p< 0.01
VJT(cm)	- 0.167	- 0.225 to - 0.107	p< 0.05	- 0.217	- 0.274 to - 0.158	p< 0.01
SLJ(cm)	- 0.091	- 0.129 to - 0.008	0.0261	- 0.145	- 0.204 to - 0.084	p< 0.05
ns = not significant, 95 % CI = 95% confidence intervals						

HRT = hand reaction time; FRT = foot reaction time; SOM = speed of movement; 30 MS = 30 meter sprint; VJT = vertical Jump test; SLJT = standing long jump test

5.15. Pearson's Product-moment correlation coefficient of WHR and WTR with selected motor quality parameters

Variables	WHR			WTR		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
HRT(sec)	0.466	0.417 to 0.513	p< 0.001	0.412	0.360 to 0.461	p< 0.001
FRT(sec)	0.582	0.541 to 0.621	p< 0.001	0.583	0.541 to 0.622	p< 0.001
SOM(sec)	0.425	0.374 to 0.474	p< 0.001	0.514	0.468 to 0.558	p< 0.001
Agility(sec)	0.738	0.709 to 0.765	p< 0.001	0.604	0.564 to 0.641	p< 0.001
30 MS (sec)	0.580	0.538 to 0.619	p< 0.001	0.606	0.566 to 0.643	p< 0.001
VJT(cm)	- 0.594	-0.632 to -0.553	p< 0.001	- 0.568	- 0.607 to - 0.525	p< 0.001
SLJ(cm)	- 0.491	-0.536 to -0.443	p< 0.001	- 0.549	- 0.590 to - 0.505	p< 0.001
ns = not significant, 95 % CI = 95% confidence intervals						

HRT = hand reaction time; FRT = foot reaction time; SOM = speed of movement; 30 MS = 30 meter sprint; VJT = vertical Jump test; SLJT = standing long jump test

5.3.10. Determination of association of WHR and WTR with selected motor quality parameters

Pearson product-moment correlation coefficients of WHR and WTR with selected motor quality parameters are presented in Table 5.15. It is evident from the table 5.15 that WHR and WTR had significant ($p<0.001$) and positive correlation with time related motor quality parameters (i.e., HRT, FRT, SOM, agility and sprint). A significant ($p<0.001$) and negative correlation was obtained between WHR and length related motor quality parameters (i.e., VJT and SLJT) and also a significant ($p<0.001$) and negative correlation was obtained between WTR and length related motor quality parameters.

5.3.11. Multiple linear regression analysis

Multiple linear regression analysis was performed to see the independent relationship of different anthropometric obesity parameters with selected motor quality parameters those are representative of motor quality development and standard partial regression coefficients (β) have been presented for this purpose (Table 5.16 and 5.17). The models were controlled several factors.

Table 5.16. Multiple regression analysis of HRT, FRT, agility, 30 meter sprint, VJT and SLJT on age, BMI, body fat%

Independent Variable	Constant (A)	Unstandarzied coefficient		Standarized coefficient	t	Level of Significance	F	Level of Significance	R^2
		B	Std. Error	Beta (β)					
Hand reaction time (HRT) is dependent variable									
Age	0.334	- 0.014	0.001	0.565	- 22.61	p<0.001	317.76	p<0.001	0.47
BMI		0.003	0.001	0.183	2.57	p<0.001			
Body fat%		0.007	0.001	0.726	10.55	p<0.001			
Foot reaction time (HRT) is dependent variable									
Age	0.418	- 0.018	.0.000	-0.906	- 59.17	p<0.001	1417.86	p<0.001	0.80
BMI		0.001	0.001	0.074	1.68	0.093			
Body fat%		0.003	0.000	0.428	10.15	p<0.001			
Agility is dependent variable									
Age	13.250	- 0.599	0.011	- 0.883	- 54.69	p<0.001	1442.20	p<0.001	0.78
BMI		0.419	0.023	0.856	18.57	p<0.001			
FAT%		0.043	0.011	- 0.169	3.80	p<0.001			
Sprint is dependent variable									
Age	7.106	- 0.389	0.007	- 0.956	-59.75	p<0.001	1271.71	p<0.001	0.78
BMI		0.223	0.013	0.759	16.62	p<0.001			
Body fat%		0.036	0.007	- 0.328	5.39	p<0.001			
Vertical jump test (VJT) is dependent variable									
Age	21.59	3.00	0.070	0.864	42.92	p<0.001	675.31	p<0.001	0.66
BMI		-1.363	0.144	- 0.543	- 9.44	p<0.001			
Body fat%		0.071	0.073	0.054	0.982	0.032			
Standing long jump test (SLJT) is dependent variable									
Age	78.91	8.78	0.200	0.870	43.81	p<0.001	704.22	p<0.001	0.671
BMI		-2.09	0.413	- 0.287	- 5.06	p<0.001			
Body fat%		- 0.438	0.208	- 0.115	- 2.10	0.035			

In multiple regressions analysis demonstrated (Table 5.16) that all selected time related motor quality variables (i.e., HRT, 30 meter sprint and agility) were significantly (p<0.001) and positively associated with the BMI, when age and body fat% were controlled. It is also obtained from the Table 5.16 that the BMI was significantly (p<0.001) and negatively associated with length related motor quality variables (i.e., VJT and SLJT) when age and body fat% were controlled. Table 5.16 also demonstrated that age had strong independent significant (p<0.001) and negative association with all time related motor quality variables and significant negative association with length related motor quality variables. It is also observed from the Table 5.17 that even after controlling for effects of age and BMI, body fat% had independent significant (p<0.001) and positive association with time related motor quality variables (i.e., HRT, FRT, agility and sprint).

Table 5.17. Multiple regression analysis of HRT, FRT, SOM, agility, 30 meter sprint, VJT and SLJT on age, WHR, WTR

Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
Age	-0.025	-0.008	0.001	- 0.311	-10.84	p<0.001	171.16	p<0.001	0.33
WHR		0.319	0.028	0.347	11.58	p<0.001			
WTR		0.039	0.015	0.087	2.65	0.008			
Foot reaction time (HRT) is dependent variable									
Age	0.125	- 0.012	0.000	- 0.625	- 35.97	p<0.001	1053.9	p<0.001	0.75
WHR		0.282	0.013	0.384	21.12	p<0.001			
WTR		0.034	0.007	0.094	4.71	p<0.001			
Speed of movement (SOM) is dependent variables									
Age	1.259	- 0.286	0.012	- 0.421	- 24.04	p<0.001	1031.4	p<0.001	0.74
WHR		14.871	0.467	0.584	31.85	p<0.001			
WTR		1.299	0.252	0.103	5.15	p<0.001			
Agility is dependent variable									
Age	1.257	- 0.286	0.012	- 0.421	- 24.04	p<0.001	1031.69	p<0.001	0.75
WHR		14.87	0.467	0.584	31.85	p<0.001			
WTR		1.299	0.252	0.103	5.15	p<0.001			
Sprint is dependent variable									
Age	2.38	- 0.241	0.008	- 0.592	- 31.89	p<0.001	881.75	p<0.001	0.71
WHR		5.360	0.297	0.368	18.95	p<0.001			
WTR		0.926	0.160	0.123	5.78	p<0.001			
Vertical jump test (VJT) is dependent variable									
Age	70.40	1.83	0.071	0.527	25.88	p<0.001	674.44	p<0.001	0.66
WHR		- 53.61	2.780	-0.411	- 19.28	p<0.001			
WTR		-7.06	1.501	-0.109	- 4.70	p<0.001			
Standing long jump test (SLJ) is dependent variable									
Age	78.91	6.12	0.210	0.607	29.12	p<0.001	635.04	p<0.001	0.64
WHR		-106.8	8.231	- 0.282	- 12.97	p<0.001			
WTR		- 22.83	4.443	- 0.122	- 5.14	p<0.001			

On the other hand, Table 5.17 represented that waist to hip ratio (WHR)) had strong independent significant (p<0.001) and positive association with all the time related motor quality variables (i.e., HRT, FRT, agility and 30 meter sprint) and independent significant (p<0.001) and negative association with length related motor quality variables, when age and WTR were controlled. So, waist to hip ratio (WHR) is partly good predictor for variability of the selected motor quality parameters.

It is also obtained from the Table 5.17 that the WTR was significantly and positively related with HRT, FRT, agility, and 30 meter sprint and WTR also had independent significant ($p<0.001$) and negative association with gross motor skill (i.e., VJT and SLJT) when age and WHR were controlled. On the other hand, Table 5.17 represented that age had strong independent significant ($p<0.001$) and positive association with all time related motor quality variables except for length related motor quality (i.e., VJT and SLJT), where the relationship was found to be the reverse.

5.4. Discussion

It is understandable from the results of the study that overweight and obesity do have a negative effect on the health-promotional motor quality fitness of 5 to 12 years school children. The negative effect is the greatest in muscle power, speed, flexibility and fine motor skill of overweight and obese boys. In the present study hand reaction time (HRT), foot reaction time (FRT), speed of movement (SOM), agility and 30 meter sprint were found be significantly higher in overweight and obese weight categories compared to normal weight categories (Table 5.5). It is also evident from Table 5.6 to 5.12 that lowest 5^{th} to highest 95^{th} percentile values of all selected time related motor quality parameters (HRT, FRT, SOM, agility and sprint) were higher in overweight and obese categories than in normal weight boys. On other hand, lowest 5^{th} to highest 95^{th} percentile values of all selected length related motor quality parameters were higher in normal weight category. Lower level of motor skills in overweight and obese children may be associated with muscle dysfunction, as a consequence of physical inactivity, which has its indirect effect on the disorders of postural state and the emergence of physical deformities, so it was determined that children aged 5 to 12 years, they reflect the structure of the hand and foot **(Trajković & Nikolić, 2008**). Motor abilities are correlated with postural status of the lower leg and foot, especially explosive leg strength. Muscular failure occurred under these conditions, resulting in muscle strength deficit, which is expressed only later age **(Wearing et al., 2006).** Significantly lower results in tests for the assessment of speed, coordination and explosive power, in children aged 6 to 12 years old, have been observed in other studies worldwide (**Milanese et al., 2010; D'Hondt et al., 2008; Ford & Mokdad, 2008; Zhu et al., 2010**).

In our study it has been shown (Table 5.5) that the obese boys were not able to run as quickly as than in normal weight and overweight boys in same age group, similar results were found from the study of **Graf et al. (2004)** and **Morano et al., (2011)**. On the other hand, gross motor skill like jumping ability in the form of standing long jump, vertical long jump value of obese boys were very poor when compared with normal and overweight categories in the same group. This finding corroborates well with findings of **D' Hondt** and his colleagues **(2007),** they reported that children with high BMI and fat percentage affect the fine and gross motor skill under different postural constraints. Deposition of excess fat on the limb joint reduces the limb movement and decreases reflex also. Overweight and obesity influences the body geometry and increases the mass of different body segments **(Mukherjee et al., 2015).** A report of **Numez-Gaunaurd et al., 2013**) also revealed that children who were obese and overweight show much more impairments in motor proficiency and are less physically active when compared with the normal weight children. According to the study of **Tokmakidis et al. (2006)** and **Wearing et al. (2007)** showed that the overweight and obese children were significantly weaker from normal weight children in standing long-jump as well as in vertical jump performance as measurements of muscle strength. Another study of **Chen et al.** in **2006** also indicated that overweight and obese boys, as well as girls in the 6 to 18 year old age group, found significantly weaker in abdominal muscle patience tests.

On other hand, we observed significant and positive association of BMI and body fat percentage with fine motor skill (i.e., hand reaction time, foot reaction time) that has been previously reported in studies from children with different ages ranging from kindergarten to 10 years **(Kambas et., 2012; Morrison et al., 2012)** they reported that reaction time positively associated with BMI and body fat% indicates poorer motor development. Generally, there are consistent inverse correlations among weight status and motor competence **(Jones et al., 2010; Barnet et al., 2008).** Overall, these results agree with most previous result that demonstrates an inverse relationship between childhood body mass index and various measures of motor performance **(Lubans et al., 2010; Jones et al., 2010; Okely et al., 2004)**. Moreover, multiple regressions analysis demonstrated (Table 5.17) that all selected motor quality variables were significantly associated with BMI except with speed of movement where no significance observed between BMI with speed of movement.

Body fat % is the amount of body fat stored in the body and does not take into account the lean body mass and muscle mass **(Frankenfield et al., 2001; King et al., 2005).** Result from Table 5.14 revealed that body fat % and vertical jump have a significant negative association. An individual with lower body fat % definitely has a higher vertical jump **(Noorul et al., 2008; Diazon & Grimmer-Sommer, 2012**). This is because the boys with lower body fat % and greater power are more likely to generate greater velocity of jumping **(Roschel et al., 2009).** Another study done by **Davis et al. (2003)** has reported that body fat % is the best predictor of vertical jump for recreational male athletes aged between 20 to 37 years old. This result corresponds to that of **Roschel et al. (2009),** who stated that the sum of skinfold thickness has significant negative association with vertical jump height. Body fat % is related to the work performed during vertical jump and standing long jump. Since work is the product of average force acting on the subject and the displacement of the jump, obese person need more work to move the body to the same displacement achieved by non-obese individual **(Reiser et al. ,2006; Roschel et al., 2009).** Generally, there are consistent inverse correlations among weight status and motor competence **(Jones et al., 2010; Barnet et al., 2008).** Although, some studies **(Eckner et al., 2006)** has reported positive relationship between reaction time and obesity. The scores of vertical jump and standing long jump were the lowest in overweight and obese boys when compared with healthy normal weight boys, the reason for poorer performances may be the difficulty faced during moving extra load generated from excess body fat during weight bearing task **(Chen et al., 2002; Manila et al., 1995)**.

Motor skill constitutes a significant developmental challenge during preschool years. The results showed (Fig 5.1 to 5.5) an improvement in reaction time with increase of age. The mean values of hand reaction (HRT), foot reaction time (FRT), speed of movement (SOM), agility and 30 meters sprint were gradually decreased with advancement of age among three body weight categories of boys. Thus the older boys were taken less time to complete motor activity than that of younger ones. Other investigators reported age-related improvement in visual motor **(Gabbard & Hart, 1993)** and balance skills **(Venetsanou & Kambas, 2011)** during preschool years. Moreover, during early childhood motor fitness improves with age **(Arceneaux et al., 1997; Benefice et al., 1999; Davies & Rose, 2000; Butterfield et al., 2002).** Accordingly, we found a significant ($P<0.001$) relationship between age and motor development. Our study have also shown (Fig 5.6 & 5.7) that the mean values of vertical jump and standing long jump were significantly ($p<0.01$) higher in 11 to < 13 years old boys compared to the resting age groups in three body weight categorise because this age group represents the onset of adolescence. In the onset of puberty or during puberty, children obtain the capability to take higher advantages of elastic energy storage in the musculotendinous system while performing peak counter-movement jumps **(Korff et al., 2009)**. Many factors are known that affect growth and development like age, body mass, body fat percentage **(Johnston et al., 1980).** Hereditary **(Susanne, 1980)** as well as environmental factors are important in the process of growth and development. Multiple regression analysis demonstrated (Table 5.16 & 5.17) that even after controlling for the effect of anthropometric indices (BMI, body fat %, WHR and WTR), the age had independent strong significant ($p<0.001$) and negative impact on reaction time related (HRT, FRT, agility and 30 meter sprint) motor quality variables and significant positive association with vertical jump test (VJT) and standing long jump (SLJ).

The gradual improvement of motor skill from age 5 to10 years, suggested an underlying maturational process of the cortex and corticospinal tracts. Magnetic resonance imaging (MRI) **(Paus et al., 2001)** specifically relevant to age-related study showed that age related improvement of children due to continue growth of corpus callosum from childhood to adult hood when he compared with growth of corpus callosum from childhood to adulthood. **Paus et al. (1999)** demonstrated that the corticospinal and thalamocortical tracts that support motor functions also demonstrate age-related maturation.

The results of the present study (Table 5.15) showed that WHR and WTR do have significant and negative effects upon the gross motor skill (i.e., VJT, SLJ, agility and 30 meter sprint), and significant and positive effect on fine motor skill (i.e., HRT, FRT and SOM). This present study is possibly the first study on Bengali children report significant negative impact of WHR and WTR on motor development skill in an example of health.

Visceral adiposity is inversely correlated with cognitive skill and cognitive skill partly associated with motor performance skill. High visceral adiposity is associated with smaller hippocampus and larger ventricular volume **(Isaac et al., 2011).** There is also a negative correlation between waist-to-hip ratio and hippocampal volume and a positive correlation between waist to-hip ratio and white matter hyperintensities (**Jagust et al., 2005).** Neuroimaging studies demonstrate atrophy in the frontal lobes, anterior cingulate gyrus, hippocampus, and thalamus in older obese individuals **(Raji et al., 2010).**

BMI increase is associated with lower metabolic activity in the prefrontal cortex and cingulate gyrus, smaller gray matter volume in many brain regions (particularly prefrontal cortex), and deficient white matter integrity in the uncinated fasciculus which is structure connecting the frontal and temporal lobes **(Bolzeniu et al., 2015; Taki et al., 2008; Volkow et al., 2009; Walther et al., 2010; Willette et al., 2015)**.

Smaller gray matter volume in the left orbitofrontal region is related to poorer executive and motor performance in obese women **(Walther et al., 2010).** Moreover, high BMI & visceral obesity are related to neuron and myelin abnormalities **(Gazdzinski et al., 2008)**. On the other hand, lower self-esteem in overweight and obese children had also been linked to poor motor and cognitive skill.

5.5. Conclusion

In cross-sectional studies, children who were overweight or obese performed much poorer in fine and gross motor skill compared to normal weight categories. From the study also showed an improvement in motor skills with the increase of age. Motor quality parameters significantly correlated with age, BMI, body fat% and waist to hip ratio, and waist to thigh ratio. Higher level of BMI and body fat percentage has a negative effect on motor development in overweight and obese boys, thus it should be considered as a serious problem. It is essential to identify strengths and weakness as in fine and gross motor skills as early as possible. The earlier the movement deficit is identified, and the longer an appropriate motor performance program is carried out, the better the result may be. Findings of this study clearly show that fine and gross motor development of school children is related to overweight and obesity. Thus, overweight and obese children need plenty of opportunities to practice and refine their fine and gross motor skills. Improving motor skill during childhood is a schedule to influence young people's present and future physical activity.

Childhood Obesity & Physiological Parameters

Chapter VI

6.1. Introduction

Childhood obesity is a growing problem in developing countries and is likely a major cause of the increased prevalence of high blood pressure in children. Association between obesity indices and hypertension in children has been reported in several studies among a variety of ethnic and racial groups, with virtually all studies finding higher blood pressures and higher prevalences of hypertension in obese and overweight compared with normal weight children **(Verma et al., 1994; Anand & Tandon, 1996; Freedman et al., 1999; Sorof et al., 2002; Mohan et al., 2004).**

Several researches indicate that obesity tracks from childhood to adulthood and constitutes as a risk factor in the development of chronic diseases **(Sinaiko et al., 1999).** Higher body mass index (BMI) and body fat% are responsible for releasing a great amount of inflammatory adipokines into the bloodstream which has an important role in the pathogenesis of many chronic diseases (**Huang, 2009; Kotsis et al., 2010**), and also in the changes of sympathetic and parasympathetic activity in children and adolescents, which can result in an increased resting heart rate **(Rabbia et al., 2002; Al-Qurashi et al., 2009; Baba et al., 2007; Fernandes et al., 2011).**

In adults, the use of resting heart rate as screening index for cardiovascular risk has been postulated **(Palatine et al., 2010; Palatini, 2009)**, and supported by studies that reported its relationship to mortality, independent of abdominal obesity **(Oda & Kawai, 2009)**, but few studies are found which focus on the obese pediatric population. Recently, **Fernandes et al., (2010)** identified that a higher resting heart rate was associated with elevated blood pressure, in both normal weight and obese children and adolescents, independent of age and ethnicity. However, it is not clear if resting heart rate can also be applied as a screening for other risk factors, such as hyperglycemia and dyslipidemia.

On the other hand, obesity has a profound effect on the physiology of breathing. An important respiratory abnormality in obesity is a decrease in total respiratory system compliance, which is supported by the work of **Naimark & Cherniack (1960)**. They have demonstrated that total respiratory compliance is reduced by as much as two-thirds of the normal value in obese individuals.

Obese individuals tend to have a rapid, shallow breathing pattern in patients with neuromuscular disorders and deformities of the chest wall. The oxygen (O_2) cost of breathing is less for given ventilation when the respiratory rate is high and the tidal volume is small **(Parameswaran et al., 2006).**The main finding of the study was to understand the influence of obesity indices (i.e., BMI, body fat %, waist to hip ratio and waist to thigh ratio) on certain physiological parameters (blood pressure, resting pulse rate and resting respiratory rate) from boys aged boys aged 5 to 12 years from state of West Bengal, India.

6.2. Materials and Methods

The present study was conducted in 1036 school going boys aged between five to twelve years. The total number of subjects were subdivided into four age groups such as 5 - <7 years, 7 - <9 years, 9 - <11 years and 12 – <13 years. Each age group was also divided into three body weight categorised i.e., normal weight, overweight and obese on the basis of BMI-age-boys Z-scores **(WHO, 2007).**

All the selected physiological parameters such as resting blood pressure (SBP & DBP), resting heart rate and resting respiratory rate were determined by standard procedures those have been elaborately discussed in Chapter III.

6.3. Results

6.3.1. Range of selected physiological parameters of three body weight categories in 5 - <7 years old boys

Table 6.1 shows that the mean resting pulse rate of normal weight boys was 105.58 bpm (range 80 to 133bpm), resting respiratory rate 22.82 cpm (range 18 to 29 cpm), SBP 93.92 mmHg (range 74 to 112 mmHg), and DBP 55.10 mmHg (range 42 to 71 mmHg).

Moreover, mean resting pulse rate of overweight categories was 106.40 bpm (range 84 to 126 bpm), resting respiratory rate 23.81 cpm (range 18 to 29 cpm), SBP 96.81 mmHg (range 78 to 114 mmHg), and DBP 58.24 mmHg (range 46 to 74 mmHg).

Oppositely, mean resting pulse rate of obese categories was 114.23 bpm (range 93 to 134 bpm), resting respiratory rate 25.45 cpm (range 20 to 35 cpm), SBP 102.30 mmHg (range 90 to 118 mmHg), and DBP 62.14 mmHg (range 50 to 76 mmHg). It is also noted from Table 6.1 that maximum level of respiratory rate of obese categories was found to be greater than 35 cpm i.e., the upper limit of normal range of reparatory rate **(PALS Guidelines, 2016).** On the other hand, maximum levels of SBP & DBP were found to be higher than recommended range in overweight and obese categories **(PALS Guidelines, 2016).**

6.3.2. Range of selected physiological parameters of three body weight categories in 7 - <9 years old boys

Table 6.2 demonstrates that the mean resting pulse rate of normal weight boys was 100.27 bpm (range 70 to 123 bpm), resting respiratory rate 22.52 cpm (range 18 to 30 cpm), SBP 98.03 mmHg (range 86 to 115 mmHg), and DBP 58.94 mmHg (range 46 to 74 mmHg).

In contrast, mean resting pulse rate of overweight boys was 102.11 bpm (range 75 to 124 bpm), resting respiratory rate 22.77 cpm (range 18 to 30 cpm), SBP 100.26 mmHg (range 90 to 116 mmHg), and DBP 62.27 mmHg (range 52 to 76 mmHg).

It is noted from the Table 6.2 that mean resting pulse rate of obese boys was 106.81 bpm (range 80 to 129 bpm), resting respiratory rate 22.77 cpm (range 20 to 34 cpm), SBP 103.34 mmHg (range 90 to 118 mmHg), and DBP 64.11 mmHg (range 52 to 80 mmHg). It is also noted from Table 6.2 that upper level of respiratory rate of obese boys was found to be greater than 30 cpm i.e., the upper limit of normal range of respiratory rate **(PALS Guidelines, 2016).** In contrast, highest level of pulse rate was found to be higher than the recommended range in obese boys. On the other hand, highest levels of SBP & DBP were found to be higher than recommended range in overweight and obese boys **(PALS Guidelines, 2016).**

Table 6.1. Mean, standard deviation (SD), median and range of selected Physiological parameters of three body weight categories (Total number of boys = 245, number of normal weight boys = 142, number weight boys overweight = 61, number of obese boys = 42) under the age group of 5 – <7 years

Categories	Variables	Mean	SD	Median	Range		*Paediatric range	
					Minimum	Maximum	Minimum	Maximum
NW	Pulse rate (bpm)	105.58	13.27	107	80	133	80	140
OW		106.40	13.82	110	84	126		
OB		114.23	12.42	117	93	134		
NW	Respiratory rate (cpm)	22.82	2.83	24	18	29	22	34
OW		23.81	3.77	24	18	32		
OB		25.45	4.50	24	20	35		
NW	SBP (mmHg)	93.92	8.67	94	74	112	89	112
OW		96.81	10.73	97	78	114		
OB		102.30	8.41	100	90	118		
NW	DBP (mmHg)	55.10	7.09	54	42	71	46	72
OW		58.24	9.46	54	46	74		
OB		62.14	7.52	60	50	76		

***(PALS Guidelines, 2016);** NW = normal weight, OW = overweight, OB = obese

Table 6.2. Mean, standard deviation (SD), median and range of selected Physiological parametrs of three body weight categories (Total number of boys = 261, number of normal weight boys = 146, number of overweight boys = 72, number of obese boys = 43) under the age group of 7 – <9 years

Categories	Variables	Mean	SD	Median	Range		*Paediatric Range	
					Minimum	Maximum	Minimum	Maximum
NW	Pulse rate (bpm)	100.27	13.99	102	70	123	70	120
OW		102.11	13.25	105	75	124		
OB		106.81	13.84	110	80	129		
NW	Respiratory rate (cpm)	22.52	3.14	23	18	30	18	30
OW		22.77	3.44	22	18	30		
OB		24.95	4.30	24	20	34		
NW	SBP (mmHg)	98.03	8.21	97	86	115	97	115
OW		100.26	6.63	99	90	116		
OB		103.34	9.08	100	90	122		
NW	DBP (mmHg)	58.94	7.44	56	46	74	57	76
OW		62.27	6.49	62	52	76		
OB		64.11	8.61	64	52	80		

***(PALS Guidelines, 2016);** NW = normal weight, OW = overweight, OB = obese

6.3.3. Range of selected physiological parameters of three body weight categories in 9 - <11 years old boys

It is noted from the Table 6.3 that in normal weight boys the mean resting pulse rate was 94.49 bpm (range 66 to 114 bpm), resting respiratory rate 19.76 cpm (range 14 to 27 cpm), SBP 100.72 mmHg (range 90 to 120 mmHg), and DBP 60.36 mmHg (range 50 to 76 mmHg).

Moreover, mean resting pulse rate of overweight boys was 96.34 bpm (range 65 to 120 bpm), resting respiratory rate 21.36 cpm (range 14 to 28 cpm), SBP 104.42 mmHg (range 94 to 122 mmHg), and DBP 64.76 mmHg (range 54 to 80 mmHg).

It is observed from the Table 6.3 that mean resting pulse rate of obese boys was 99.90 bpm (range 75 to 120 bpm), resting respiratory rate 21.43 cpm (range 15 to 28 cpm), SBP 107.43 mmHg (range 94 to 124 mmHg), and DBP 67.33 mmHg (range 56 to 84 mmHg **).**

It is also noted from Table 6.3 that maximum level of respiratory rate of obese and overweight categories were found to be greater than 25 cpm i.e., the upper limit of normal range of respi ratory rate **(PALS Guidelines, 2016).** In contrary, maximum level of pulse rate was found to be higher in obese categories than the recommended range. Table 6.3 also shows that upper levels of SBP & DBP were found to be higher than recommended range in overweight and obese categories **(PALS Guidelines, 2016).**

Table 6.3. Mean, standard deviation (SD), median and range of selected Physiological parameters of three body weight categories (Total number of boys = 263, number of normal weight boys = 146, number of overweight boys = 63, number of obese boys = 53) under the age group of 9 – <11 years

Categories	Variables	Mean	SD	Median	Range		*Paediatric Range	
					Minimum	Maximum	Minimum	Maximum
NW	Pulse rate (bpm)	94.09	12.82	97	66	114	70	120
OW		96.34	15.12	99	65	120		
OB		99.90	13.66	105	75	123		
NW	Respiratory rate (cpm)	19.76	3.78	20	14	27	18	25
OW		21.36	3.62	21	14	28		
OB		21.43	3.91	20	15	28		
NW	SBP (mmHg)	100.72	7.29	100	90	120	97	115
OW		104.42	8.16	104	94	122		
OB		107.43	8.33	108	94	124		
NW	DBP (mmHg)	60.36	6.90	60	50	76	57	76
OW		64.76	7.59	64	54	80		
OB		67.33	7.99	66	56	84		

***(PALS Guidelines, 2016);** NW = normal weight, OW = overweight, OB = obese

6.3.4. Range of selected physiological parameters of three body weight categories in 11 - <13 years old boys

It is observed from the Table 6.4 that the mean resting pulse rate of normal weight boys was 87.79 bpm (range 60 to 110 bpm), resting respiratory rate 18.46 cpm (range 12 to 24 cpm), SBP 104.19 mmHg (range 94 to 122 mmHg), and DBP 62.11 mmHg (range 52 to 80 mmHg).

Table 6.4. Mean, standard deviation (SD), median and range of selected Physiological parameters of three body weight categories (Total number of boys = 267, number of normal weight boys = 139, number overweight boys = 82, number of obese boys = 46) under the age group of 11 – <13 years

Categories	Variables	Mean	SD	Median	Range		*Paediatric Range	
					Minimum	Maximum	Minimum	Maximum
NW	Pulse rate (bpm)	87.89	14.57	87	60	110	70	120
OW		90.70	15.29	91	62	114		
OB		95.13	13.14	96	75	116		
NW	Respiratory rate (cpm)	18.46	3.55	19	12	24	12	25
OW		19.15	3.70	20	13	26		
OB		20.28	3.97	20	14	26		
NW	SBP (mmHg)	104.19	7.47	104	94	122	102	120
OW		111.01	6.87	112	100	124		
OB		114.41	9.48	112	100	136		
NW	DBP (mmHg)	62.11	7.35	62	52	80	61	82
OW		66.93	8.11	66	54	84		
OB		72.26	8.64	71	56	90		

***(PALS Guidelines, 2016);** NW = normal weight, OW = overweight, OB = obese

On the other hand, in overweight boys mean resting pulse rate was 90.70 bpm (range 62 to 114 bpm), resting respiratory rate 19.15 cpm (range 13 to 26 cpm), SBP 111.01 mmHg (range 100 to 124 mmHg), and DBP 66.93 mmHg (range 54 to 84 mmHg).

It is also observed from the Table 6.4 that in obese boys mean resting pulse rate was 95.13 bpm (range 75 to 116 bpm), resting respiratory rate 20.28 cpm (range 14 to 26 cpm), SBP 114.41 mmHg (range 100 to 136 mmHg), and DBP 72.26 mmHg (range 56 to 90 mmHg).

It is also noted from Table 6.4 that maximum level of respiratory rate of obese boys was found to be greater than 25 cpm i.e., the upper limit of normal range of reparatory rate **(PALS Guidelines, 2016).**Table 6.4 shows that highest levels of SBP & DBP were found to be higher in overweight and obese boys than recommended range (PALS Guidelines, 2016).

6.3.5. Comparisons of selected physiological parameters among three body weight categories in four different age groups

Comparison of selected physiological parameters among normal weight, overweight and obese boys in four different age groups has been presented in Table 6.5. One way ANOVA was performed to make an overall comparison of the selected physiological parameters among three body weight categories in each of the four age groups. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group.

The results of one way ANOVA showed a significant variation ($p<0.05$) of all selected physiological parameters among three body weight categories in four different age groups. It is evident from the Table 6.5 that obese categories had significant higher values of pulse rate than normal weight boys in all age groups. Moreover, in post hoc Scheffe's multiple comparison tests showed that pulse rate significantly ($p<0.05$) higher in obese boys compared to normal weight boys in all age groups.

It was also observed from Table 6.5 that obese boys had significantly higher values ($p < 0.05$) of resting pulse rate than overweight boys in 5 – <7 years age group. It is noted from the Table 6.5 that mean values of resting respiratory rate was higher in obese boys than found in normal weight boys in all selected age groups. On the other hand, the mean values resting respiratory rate was significantly ($p < 0.05$) lower in overweight boys than normal weight boys in 9 – <11 and 11 – <13 years age group. In contrast, mean values of resting SBP and DBP were significantly ($p < 0.05$) higher in obese boys compared to the normal weight boys in all age groups. Alternatively, overweight boys also exhibited significantly ($p < 0.05$) lower values of resting diastolic blood pressure (DBP) than obese boys in all age groups.

But no such significant difference was observed in resting systolic blood pressure in between overweight and obese boys in 7 – < 9 years age group. It is also noted from Table 6.5 that a significant ($p < 0.05$) difference existed in diastolic pressure (DBP) between the overweight and normal weight boys in every age specific strata. On the other hand, systolic blood pressure (SBP) of overweight boys were found to be higher compared to the normal weight boys in 9 – <11 and 11 – <13 years age groups.

Table 6.5. Comparisons of selected physiological parameters among three body weight categories of four age groups

Age group (years)	Category	Resting pulse rate (bpm)	Resting respiratory rate (cpm)	Resting blood pressure (mmHg)	
				SBP	DBP
5 – 6 > (N=245)	NW (a), (n =142)	105.58 ± 13.27	22.82 ± 2.83	93.92 ± 8.67	55.10 ± 7.09
	OW (b), (n =61)	106.40 ± 13.87	23.81 ± 3.77	96.81 ± 10.73	58.24 ± 9.46
	OB (c),(n = 42)	114.23 ± 12.42	25.45 ± 4.5	102.48 ± 8.44	62.14 ± 7.52
F value		7.06	9.91	14.06	14.02
Level of significance		*(ac) (bc)	*(ac)	*(ac)(bc)	*(ab)(bc)(ac)
7 – 9 > (N = 261)	NW (a), (n =146)	100.27 ± 13.99	22.52 ± 3.14	98.03 ± 8.21	58.94 ± 7.44
	OW(b), (n =72)	102. 11 ± 13.25	22.77 ± 3.44	100.26 ± 6.63	62.27 ± 6.49
	OB(c), (n = 43)	106. 81 ± 13.84	24.95 ± 4.30	103.34 ± 9.08	64.11 ± 8.61
F value		3.76	8.49	7.81	10.29
Level of significance		*(ac)	*(ac) (bc)	*(ac)	*(ab)(ac)
9 – 11 > (N = 263)	NW (a), (n =147)	94.09 ± 12.82	19.76 ± 3.78	100.72 ± 7.29	60.36 ± 6.90
	OW(b), (n = 63)	96.34 ± 15.12	21.36 ± 3.62	104.42 ± 8.16	64.76 ± 7.59
	OB (c), (n = 53)	99.90 ± 13.56	21.43 ± 3.91	107.43 ± 8,33	67.33 ± 7.99
F value		3.63	6.09	16.16	20.74
Level of significance		*(ac)	*(ac) (bc)	*(ab)(ac)	*(ab)(ac)
11 – 13 > (N = 267)	NW (a), (n = 139)	87.89 ± 14.57	18.46 ± 3.55	104.19 ± 7.47	62.11 ± 7.35
	OW (b), (n = 82)	90.70 ± 15.29	19.19 ± 3.70	111.01 ± 6.87	66.93 ± 8.11
	OB (c), (n = 46)	95.13 ± 13.14	20.28 ± 3.97	114.41 ± 9.48	72.26 ± 8.64
F value		4.39	4.41	39.34	19.31
Level of significance		*(ac)	*(ac)	**(ab)(ac)	*(ab)(bc)(ac)

Values are mean ± SD

'N' indicates that total number of subjects in specific age group and 'n' indicates total number of subject in each body category. One way ANOVA (expressed by F values and level of significance) was performed to show the overall difference of the selected physiological parameters among three body weight categories in each age group (*$p < 0.05$, **$p < 0.01$). Scheffe's multiple comparison tests was performed in every pair of three body weight categories a, b and c; where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'; NW = normal weight, OW = overweight, OB = obese; SBP = systolic blood pressure, DBP = diastolic blood pressure

6.3.6. Comparisons of selected physiological parameters among four age groups in each body weight category of boys

Comparisons of selected physiological parameters among four age groups in each of three body weight categories have been presented in Fig. 6.1 to 6.4. The results of one way ANOVA showed a significant variation ($p<0.05$) of selected physiological parameters among four age groups of all three body weight categories.

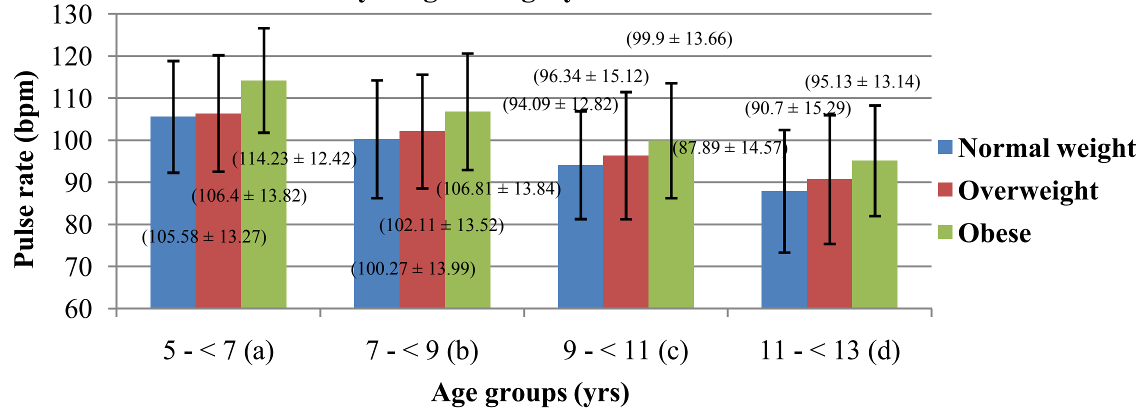
From the results it appears that the mean values of resting pulse rate (Fig. 6.1), and respiratory rate (Fig. 6.2), gradually decreased from lower age group to higher age groups in all three body weight categories. Moreover, by post hoc analysis Scheffe's multiple comparisons showed that the boys belonging to the lower age group had significant ($p<0.05$) higher resting pulse rate and resting respiratory rate compared to rest of the age groups of three body weight categories.

On the other hand, values of systolic blood pressure (Fig. 6.3) and diastolic blood pressure (Fig. 6.4) showed a significant ($p<0.05$) gradual increase with the increase of age. By post hoc analysis Scheffe's multiple comparisons showed that the boys belonging to the lower age group significantly ($p<0.05$) lower systolic blood pressure (SBP) and diastolic blood pressure (DBP) compared to rest of the age groups in each of three body weight categories.

6.3.7. Comparisons of percentile values of selected physiological parameters among three body weight categories of boys in four age groups

Comparison of 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentiles of selected physiological parameters of each of three body weight categories in four different age groups are presented in Table 6.6 to 6.9.

Fig. 6.1. Comparisons of resting pulse rate among four age groups in each of three body weight category



Values are mean ± SD

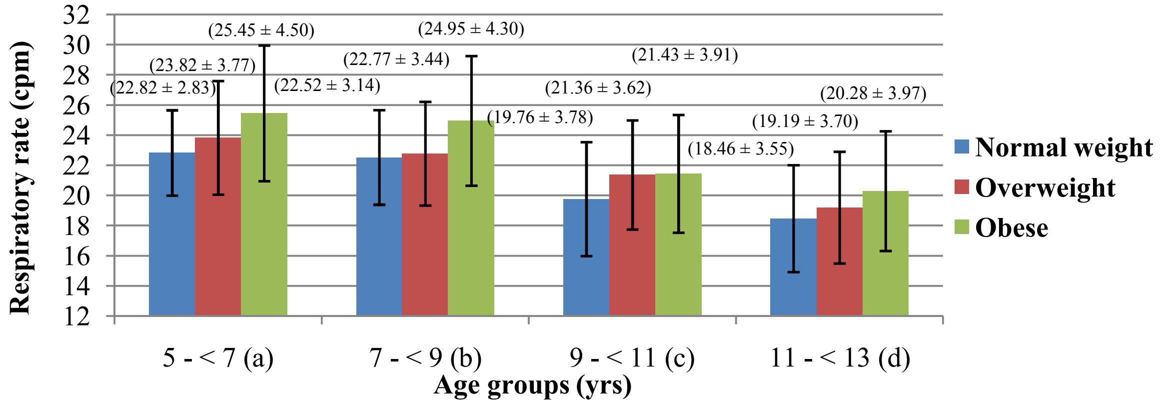
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of resting pulse rate among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

For Normal weight boys, F = 44.20 ($p<0.05$); ab, ac, ad, bc, bd, cd.

For Overweight boys, F = 16.03 ($p<0.05$); ac, ad, bd.

For Obese boys, F = 13.14 ($p<0.05$); ac, ad, bd

Fig. 6.2. Comparison of resting respiratory rate among four age groups in each of three body weight category



Values are mean ± SD

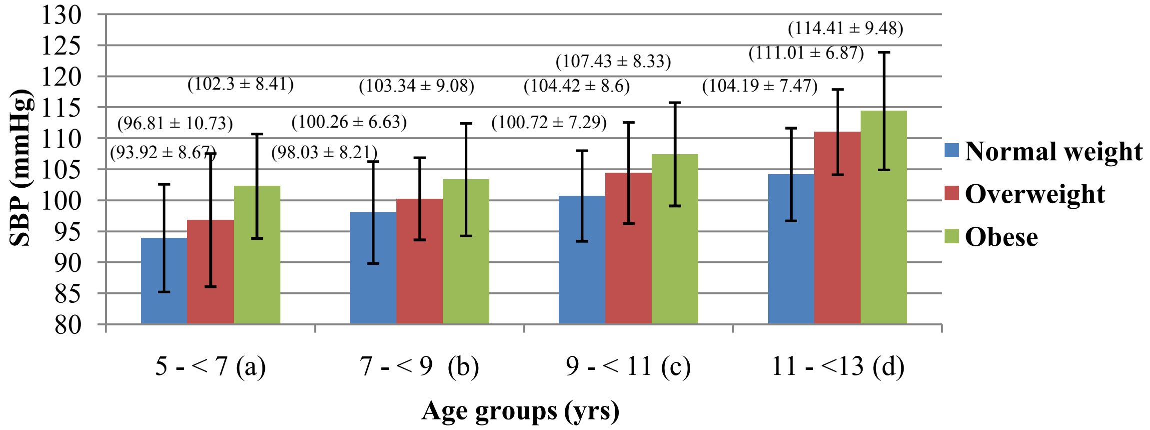
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of resting respiratory rate among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'.

For Normal weight boys, F = 57.19 ($p<0.05$); ac, ad, bc, bd.

For Overweight boys, F = 22.13 ($p<0.05$); ac, ad, bd. cd

For Obese boys, F = 17.01 ($p<0.05$); ac, ad, bc, bd.

Fig. 6.3. Copmparison of SBP among four age groups in each of three body weight category



Values are mean ± SD

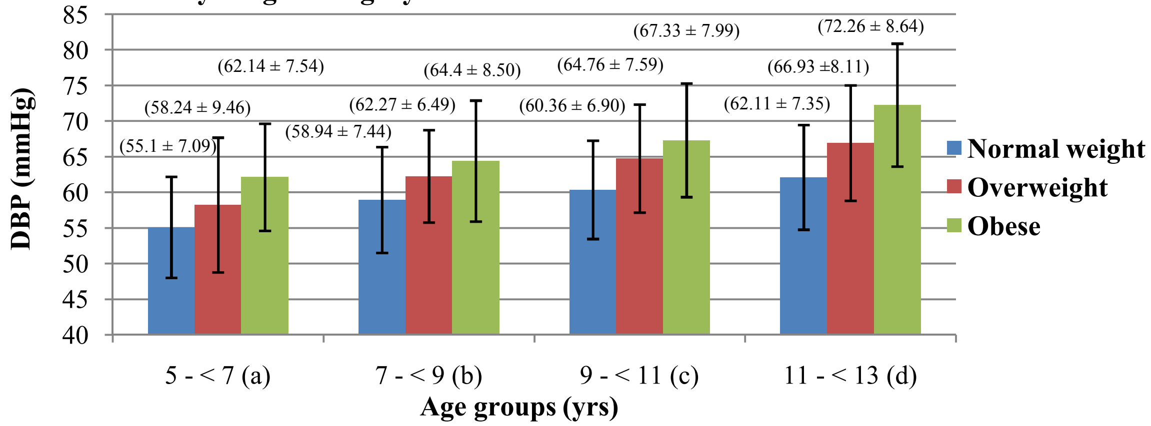
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of SBP among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; SBP = systolic blood pressure.

For Normal weight boys, F = 119.94 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 475.39 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Obese boys, F = 130.30 ($p<0.05$); ab, ac, ad, bc, cd, bd

Fig. 6.4. Comparison of DBP among four age groups in each of three body weight category



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of DBP among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd', (cd) indicates 'c' significantly ($p < 0.05$) differed from 'd'; DBP = diastolic blood pressure.

For Normal weight boys, F = 119.94 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Overweight boys, F = 475.39 ($p<0.05$); ab, ac, ad, bc, cd, bd

For Obese boys, F = 130.30 ($p<0.05$); ab, ac, ad, bc, cd, bd

It is observed from the Table 6.6 that the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th} and 95^{th} percentile values of resting pulse rate were higher in obese boys than in normal weight boys in all age group. On the contrary, highest percentile values (95^{th}) of resting pulse rate were found to be lower in overweight boys than in obese boys in same age groups.

It is noted also from the Table 6.7 that the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th} and 95^{th} percentile values of resting respiratory rate, were higher in obese boys than in normal weight boys in all age group. On the other hand, highest percentile values (95^{th}) of resting respiratory were found to be higher in overweight boys than in normal weight boys in same age groups. Again it is evident from the Table 6.8 & 6.9 that the lowest (5th) to highest (95^{th}) percentiles values of resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were higher in obese boys than in overweight boys in similar age group. It is also observed from the Table 6.8 that the 50^{th} to 95^{th} percentile values of resting systolic blood pressure were found to be higher in overweight categories than in normal weight categories in same chronological age. The result from the Table 6.9 shows that the 50^{th} to 95^{th} percentile values of hip DBP were higher in overweight boys than in normal weight boys in identical age groups.

6.3.8. Determination of association age with selected physiological parameters

Correlation coefficients of physiological parameters in respect to age were presented in Table 6.10 Correlation analysis demonstrates that age was significantly ($p<0.001$) and negatively correlated with resting pulse rate and resting respiratory rate. In contrast, result also showed that age had significant ($p<0.001$) and positive correlation with resting systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Table 6.6. Comparison of selective percentiles values of resting pulse rate among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 245)	142	NW	105.58	13.27	84	86	94	107	117	122	124
	61	OW	106.40	13.82	86	86	90	110	117	122	126
	42	OB	114.23	12.42	94	94	106	117	124	128	130
7 - < 9 (N = 261)	146	NW	100.27	13.99	74	77	90	102	112	116	120
	72	OW	102.11	13.25	78	80	94	105	113	117	118
	43	OB	106.81	13.84	85	86	95	110	117	124	126
9 - < 11 (N = 263)	147	NW	94.05	12.79	74	75	85	96	105	110	110
	63	OW	96.34	15.12	70	74	87	99	110	113	114
	53	OB	99.94	13.79	75	78	88	105	110	114	118
11 - < 13 (N = 267)	139	NW	87.79	14.57	65	67	76	87	102	105	106
	82	OW	90.70	15.29	65	66	78	91	105	108	111
	46	OB	95.13	13.14	76	78	84	96	106	112	114

NW = normal weight; OW = overweight; OB = obese

Table 6.7. Comparison of selective percentiles values of resting respiratory rate among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 245)	142	NW	22.82	2.83	18	19	20	24	25	26	26
	61	OW	23.81	3.77	18	18	21	24	26	30	30
	42	OB	25.45	4.50	20	22	22	24	28	33	35
7 - < 9 (N = 261)	146	NW	22.52	3.14	18	18	20	23	25	26	27
	72	OW	22.77	3.44	18	19	20	22	25	28	29
	43	OB	24.95	4.30	20	20	21	24	27	32	34
9 - < 11 (N = 263)	147	NW	19.76	3.78	14	15	16	20	23	25	26
	63	OW	21.36	3.62	16	17	18	21	25	26	27
	53	OB	21.43	3.91	16	16	18	20	25	27	28
11 - < 13 (N = 267)	139	NW	18.46	3.55	12	13	16	19	21	23	24
	82	OW	19.19	3.70	13	14	16	20	21	24	25
	46	OB	20.28	3.97	14	15	17	20	24	26	26

NW = normal weight; OW = overweight; OB = obese

Table 6.8. Comparison of selective percentiles values of resting SBP among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - <7 (N = 245)	142	NW	93.92	8.67	78	82	88	94	100	106	108
	61	OW	96.81	10.73	80	80	88	97	106	112	112
	42	OB	102.30	8.41	92	94	95	100	109	115	116
7 – <9 (N = 261)	146	NW	98.03	8.21	86	88	92	97	106	110	112
	72	OW	100.26	6.63	90	92	95	99	105	108	114
	43	OB	103.34	9.08	92	94	96	100	111	117	118
9 – <11 (N = 263)	147	NW	100.72	7.29	90	92	95	100	106	110	114
	63	OW	104.42	8.16	94	94	96	104	110	116	116
	53	OB	107.43	8.33	96	97	100	108	112	118	122
11 – <13 (N = 267)	139	NW	104.19	7.42	94	94	98	104	110	116	118
	82	OW	111.01	6.87	100	100	104	112	116	120	122
	46	OB	114.41	9.48	102	104	106	112	122	128	130

NW = normal weight, OW = overweight, OB = obese

Table 6.9. Comparison of selective percentiles values of resting DBP among three body weight categories of four different age groups

Age group (years)	Frequency	Category	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 – <7 (N = 245)	142	NW	55.10	7.09	46	46	50	54	60	65	68
	61	OW	58.24	9.46	46	47	48	54	67	72	73
	42	OB	62.14	7.52	54	54	56	60	68	73	74
7 – <9 (N = 261)	146	NW	58.94	7.44	48	50	54	56	66	70	72
	72	OW	62.27	6.49	53	55	57	62	68	70	74
	43	OB	64.11	8.61	53	54	57	64	72	76	77
9 – <11 (N = 263)	147	NW	60.36	6.90	52	54	54	60	65	72	72
	63	OW	64.76	7.59	55	55	56	64	72	74	76
	53	OB	67.33	7.99	56	57	60	66	74	76	82
11 – <13 (N = 267)	139	NW	62.11	7.35	54	54	54	62	66	74	76
	82	OW	66.93	8.11	56	56	62	66	74	80	82
	46	OB	72.26	8.64	60	62	66	71	78	84	86

NW = normal weight, OW = overweight, OB = obese

Table 6.10. Pearson's Product-moment correlation coefficient of age with different selected physiological parameters

Variables	Age (years) (N = 1036)		
	r	95% CI	Level of Significance
Pulse rate (bpm)	-0.386	- 0.437 to - 0.333	p< 0.001
Respiratory rate (cpm)	-0.414	- 0.464 to - 0.363	p< 0.001
SBP(mmHg)	0.412	0.361 to 0.462	p< 0.001
DBP(mmHg)	0.310	0.253 to 0.364	p< 0.001
ns = not significant, 95 % CI = 95% confidence intervals			

6.3.9. Determination of association of BMI and body fat% with selected physiological parameters

Pearson's product-moment correlation coefficients of BMI and body fat% with selected physiological parameters were presented in Table 6.11 .

Correlation analysis demonstrated that BMI and body fat% had positive but not significant correlation with resting pulse rate and resting respiratory rate. In contrast, result also showed that BMI and body fat% had significant positive correlation ($p<0.001$) with resting systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Table 6.11. Pearson's Product-moment correlation coefficient of BMI and body fat% with different selected physiological parameters

Variables	BMI (kg.m^{-2}) (N = 1036)			Body fat% (N = 1036)		
	r	95% CI	level of Significance	r values	95% CI	Level of Significance
Pulse rate (bpm)	0.069	- 0.009, to 0.13	ns	0.037	- 0.025 to 0.077	ns
Respiratory rate (cpm)	0.046	- 0.014 to 0.11	ns	0.065	- 0.003 to 0.024	ns
SBP(mmHg)	0.395	0.343 to 0.445	p< 0.001	0.342	0.287 to 0.395	p< 0.001
DBP(mmHg)	0.330	0.275 to 0.383	p< 0.001	0.285	0.228 to 0.340	p< 0.001
ns = not significant, 95 % CI = 95% confidence intervals						

SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index

6.3.10. Determination of association of WHR and WTR with selected physiological parameters

Pearson product-moment correlation coefficients of WHR and WTR with selected physiological parameters are presented in Table 6.12. It is evident from the table 6.9 that WHR and WTR had positive and significant ($p<0.001$) correlation with resting pulse rate and resting respiratory rate. A positive and significant correlation was obtained between WHR and resting blood pressure and also a positive significant correlation was obtained between WTR and resting blood pressure.

Table 6.12. Pearson's Product-moment correlation coefficient of WHR and WTR with different selected Physiological parameters

Variables	WHR (N = 1036)			WTR (N = 1036)		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
Pulse rate (bpm)	0.214	0.153 to 0.217	p< 0.001	0.250	0.192 to 0.306	p< 0.001
Respiratory rate (cpm)	0.221	0.163 to 0.279	p< 0.001	0.266	0.168 to 0.283	p< 0.001
SBP(mmHg)	0.092	0.032 to 0.152	0.0028	0.100	0.040 to 0.160	0.0012
DBP(mmHg)	0.096	0.036 to 0.156	0.0018	0.081	0.018 to 0.133	0.012
ns = not significant, 95 % CI = 95% confidence intervals						

WHR = waist to hip ratio; WTR = waist to thigh ratio

6.3.11. Multiple linear regression analysis

Multiple linear regression analysis was performed to see the independent relationship of age and anthropometric obesity indices (i.e., BMI, body fat %, WHR and WTR) with selected physiological parameters and standard partial regression coefficients (β) have been presented in view that (Table 6.13 & 6.14). Multiple regression analysis demonstrated that even after controlling for the effect of anthropometric obesity indices (i.e., BMI, body fat %, WHR and WTR), the age had independent strong significant ($p<0.001$) and negative impact on resting pulse rate and respiratory rate.

On the other hand, age was significantly ($p<0.001$), and positively associated with the resting blood pressure. Therefore, the age might be the best account for the variability of selected physiological parameters. It is also observed from the Table 6.13 that even after controlling for effects of age and body fat%, BMI had independent significant ($p<0.001$) and positive association with the resting blood pressure (i.e., SBP and DBP). It is observed from Table 6.14 that waist to hip ratio (WHR) had independent significant ($p<0.001$) relationship with all selected physiological parameters when age and waist to thigh ratio (WTR) was controlled. So, waist to hip ratio (WHR) is partly good detector for variability of all selected physiological parameters compared to BMI, WTR and body fat%.

Table 6.13. Multiple linear regression analysis of SBP and DBP on age, BMI and Body fat%

Systolic blood pressure (SBP) is dependent variable									
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of Significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
Age	69.84	1.38	0.13	0.30	9.98	p<0.001	107.58	p<0.001	0.23
BMI		1.12	0.28	0.34	3.93	p<0.001			
Body fat%		-0.10	0.14	-0.06	-0.73	0.464			
Diastolic blood pressure (DBP) is dependent variable									
Age	35.84	0.95	0.14	0.20	6.54	p<0.001	60.80	p<0.001	0.15
BMI		1.08	0.30	0.32	3.61	p<0.001			
body fat%		-0.14	0.15	-0.82	-0.93	0.351			

BMI = body mass index

Table 6.14. Multiple linear regression analysis of pulse rate, respiratory rate, BP and DBP on age, WHR and WTR

Pulse rate is dependent variable									
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of Significance	F	Level of Significance	R^2
		B	Std. Error	Beta (β)					
Age	92.71	-2.66	0.22	-0.38	-11.97	p<0.001	75.44	p<0.001	0.17
WHR		37.17	8.72	0.14	4.25	p<0.001			
WTR		-2.74	4.71	-0.02	-0.583	0.560			
Respiratory rate is dependent variable									
Age	18.63	-0.63	0.05	-0.35	-10.95	p<0.001	68.92	p<0.001	0.16
WHR		8.15	2.28	0.11	3.56	p<0.001			
WTR		0.72	1.23	0.02	0.58	0.584			
Systolic blood pressure (SBP) is dependent variable									
Age	39.66	2.23	0.14	0.48	15.73	p<0.001	97.05	p<0.001	0.22
WHR		34.64	5.56	0.20	6.23	p<0.001			
WTR		5.25	3.00	0.06	1.75	0.080			
Diastolic blood pressure (DBP) is dependent variable									
Age	9.31	1.71	0.14	0.37	11.52	p<0.001	54.42	p<0.001	0.13
WHR		31.62	5.85	0.18	5.40	p<0.001			
WTR		4.43	3.15	0.05	1.40	0.161			

WHR = waist to hip ratio; WTR = waist to thigh ratio

6.4. Discussion

The present study was based on comparative analysis of specific selective anthropometric and physiological parameters among normal weight, overweight and obese boys aged 5 to 12 years. There were marked differences in physiological parameters among three body weight categories.

Maximum range of resting pulse rate, respiratory rate and blood pressure of obese and overweight categories were found to be greater than recommended (**PALS Guidelines, 2016)** upper limit of normal range of physiological parameters (Table 6.1 to 6.4). Present study reveals that resting pulse rate, respiratory rate, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were remarkably higher in obese boys compared to normal weight and overweight categories due to higher level of BMI and body fat%. Similar results were found by **Schiel et al., (2006)** after investigating the associations and interactions between height, weight, BMI and resting blood pressure values in overweight, obese and normal weight children. They found that overweight and obese children had significantly higher blood pressure both systolic as well as diastolic than normal weight children.

The mean resting pulse rate was significantly higher in obese boys than in normal weight and overweight categories might be due to activation of the sympathetic nervous system that occurs early in the course of obesity and it was reported that the autonomic nervous system is an important contributor to the regulation of both the cardiovascular system and energy expenditure **(Benjamin et al., 1999).** Blood pressure and adiposity in children and adolescents were assessed by **Paradis et al. (2004)** and they showed that heart rate was increased in obese children which suggests some degree of increased sympathetic activity, body mass index was consistently associated with increase in SBP and DBP in all age groups.

Body fat% and the activity of the autonomic nervous system were studied by **Peterson** and **others** in 56 healthy obese men, and showed that heart rate was directly related to the percentage of body fat **(Peterson et al., 1988).** Body fat and sympathetic nerve activity subjects were studied by **Scherrer et al. (1994)** in 37 healthy subjects and they found that the resting rate of sympathetic nerve discharge to skeletal muscle was directly correlated with BMI and percent of body fat. Overweight and obesity associated sympathetic activation could represent one potential mechanism contributing to the increased incidence of cardiovascular complications in overweight and obese boys. On the other hand, the probable reason of high respiratory rate in obese boys due to the increased adiposity around ribs, diaphragm and abdomen leading to limited movement of ribs, decreased total thoracic and pulmonary volume causes reduction in chest wall compliance and preventing full excursion of the diaphragm. There are also effects of obesity on upper airway tone **(Kumar, 2013; Behera et al., 2014).**

The present study showed (Table 6.11) that age was negatively and significantly correlated with the resting heart rate. **Ostchega et al., (2011)** have shown that resting pulse rate is inversely associated with age. There is a mean resting pulse rate of 129 beats per minute (standard error, or SE, 0.9) at less than age 1 year, which decreases to a mean resting pulse rate of 96 beats/min (SE 0.5) by age 5, and further decreases to 78 beats/min (SE 0.3) in early adolescence.

It has also noted from the present study that BMI and body fat% were significantly and positively correlated with resting systolic and diastolic blood pressure. This finding corroborates well with the findings of **Shekharappa et al. (2011)** that BMI and body% were positively correlated with resting blood pressure. Obesity produces an increment in total blood volume and cardiac output due to excess body weight **(Shekharappa et al., 2011)**. The increase in blood volume in turn increases venous return to the heart, increasing filling pressures in the ventricles and increasing wall tension. This leads to left ventricular hypertrophy and this can decrease the diastolic compliance of the ventricle which can further progress to diastolic dysfunction and as wall tension increases further, can lead to systolic dysfunction. Thus through different mechanisms like increased total blood volume, increased cardiac output, left ventricular hypertrophy and further diastolic dysfunction, obesity may predispose to heart failure **(Kaltman et al., 1976).** The multiple linear regressions analysis reveals that body mass index (BMI) was significantly associated with the resting blood pressure blood pressure (i.e., SBP and DBP) after controlling the age, body fat percentage. Similar results were found by **Paradis et al. (2004)** that multiple linear regression analysis demonstrated body mass index (BMI) was consistently associated with SBP and DBP in all age-gender groups.

Berkley et al. (1998) confirmed that greater BMI in children and adolescence is associated with raised blood pressure**. Sorof & Daniels, (2002)** concluded that obesity has become an increasingly important medical problem in children and adolescents. Obese children are at approximately a 3-fold higher risk for hypertension than non-obese children **(Sorof & Daniels, 2002).** The distribution of body fat has been shown to be an important determinant of cardiovascular disease risk. The intra-abdominal fat has been identified with adverse lipid profile and hypertension in various types of patients. Waist to hip ratio (WHR) and waist to thigh ratio (WTR) are significant parameters for measuring the abdominal and general obesity.

In present study, there was a significant positive correlation of waist to hip ratio with systolic blood pressure (SBP) and diastolic blood pressure (DBP) (Table 6.12). A number of studies have also reported the positive correlation of these parameters with waist hip ratio (WHR) was extensively reported **(Shekharappa et al., 2011; Abiodun et al., 2011; Maffeis et al., 2001).** From the present study also waist to hip ratio (WHR) has been found to be a good predictor for variation of cardiovascular and cardio-respiratory parameters along with age in 5 to 12 years of boys.

6.5. Conclusion

Resting heart rate, respiratory rate and blood pressure were increased in overweight and obese children as compared to normal children. The fact that obese children have higher values of cardio-vascular risk factors like higher level of blood pressure and increased heart rate due to higher level BMI and body fat% when compared to non obese children has been further established in the present study. These children are at a higher risk of childhood onset of adult diseases. Thus, timely intervention will result in decreased adulthood morbidity and mortality due to overweight and obesity in these boys.

Childhood Obesity & Physical Fitness

Chapter VII

7.1. Introduction

Physical fitness index (PFI) is considered as an important and valuable parameter in the field of sports and exercise physiology and is very important aspect for an individual life. Body mass index (BMI), body fat% and waist to hip ratio (WHR) are useful tools for determining obesity. Health related physical fitness of children is dependent on lifestyle related factors such as daily physical activity levels. It was believed that the low physical fitness level of an individual is associated with higher mortality rate **(Takken et al., 2003).** Determination of Physical Fitness Index (PFI) is one of the important criteria to assess the cardiopulmonary efficiency of a subject. Physical fitness level of an individual depends upon on the amount of oxygen which can be transported by the body to working muscles to use that oxygen **(Choudhuri et al., 2002).**

Distribution of fat centrally, with increases waist circumference thought to reflect increases in visceral fat with age (**Harris, 2002**). The relationship between obesity indices and physical fitness index are well documented in other populations by several previous studies **(Berkey et al., 2003; Mayo et al., 2005; Shaikh et al., 2011)** which show the importance of physical fitness index in obesity management in children. Another study on the subjects of Kolkata of West Bengal in India documented similar findings **(Mukhopadhyay et al., 2005).** BMI, body fat % and waist to hip ratio, waist to thigh ratio have been used to evaluate health risks associated with overweight and obesity. The objectives of this study were to evaluate the relationship of PFI score with different anthropometric obesity parameters (i.e., BMI, body fat%, WHR and WTR) and comparison of PFI score among three body weight categories of boys aged 11 to < 13years in West Bengal.

7.2. Materials and methods

The present study was carried-out in 233 healthy school going Bengali boys aged 11 to <13years. On the basis of BMI-age-boys Z-scores (normal weight: - 2SD > BMI Z score < +1SD, overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD), boys were categorised in three subdivisions such Normal weight, Overweight and Obese **(WHO, 2007)**.

All the selected anthropometric obesity parameters (i.e., height, weight, BMI, WHR and WTR), physiological parameters (i.e., resting SBP, DBP, resting pulse rate, resting respiratory rate and physical fitness index (PFI) were determined by standard procedures which have been elaborately discussed in Chapter III.

7.3. Results

7.3.1. Comparison of selected anthropometric obesity parameters among three body weight categories of boys

Comparison of selected anthropometric obesity parameters among three body weight categories of boys are presented in Table 7.1.

One way ANOVA was performed to make an overall comparison of the selected anthropometric obesity parameters among three body weight categories. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of category. It is observed from Table 7.1 that there existed no significant difference in height among three body weight categories of boys.

On the other hand, weight, BMI, WHR, and body fat% differed significantly ($p<0.001$) among three body weight categories. Moreover, in post hoc multiple comparison tests all pairs of body weight categories showed significant difference (p<0.01) of above mentioned parameters among three body weight categories of boys.

Table 7.1. Comparison of selected anthropometric obesity parameters among three body weight categories of boys (number of normal weight boys = 125, number of overweight boys = 68, number of obese boys = 40)

Categories	Height (cm)	Body weight (kg.)	BMI ($kg.m^{-2}$)	WHR	WTR	Body fat%
NW (a)	147.34 ± 3.31	36.08 ± 2.75	16.59 ± 0.79	0.858 ± 0.026	1.549 ± 0.080	14.13 ± 2.48
OW (b)	146.85 ± 3.23	46 .93 ±3.57	21.72 ± 0.90	0.955 ± 0.024	1.647 ± 0.059	21.83 ± 0.87
OB (c)	147.01 ± 3.01	53.69 ± 5.59	24.78 ± 1.69	0.980 ± 0.022	1.753 ± 0.063	24.97 ± 1.66
Level of significance	ns	*** (ab)(ac)(bc)	*** (ab)(ac)(bc)	*** (ab)(ac)(bc)	** (ab)(ac)(bc)	*** (ab)(ac)(bc)
F values	0.18	437.58	1177.29	528.13	151.57	696.34

Values are Mean ± SD

One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected anthropometric obesity parameters among three body weight categories in 11 - < 13 years age group (** p < 0.01, *** p < 0.001, ns = not significant). Sceffe's multiple comparison tests were performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly (p < 0.05) differed from 'b', (ac) indicates 'a' significantly (p < 0.05) differed from 'c', (bc) indicates 'b' significantly (p < 0.05) differed from 'c'. BMI = body mass index, WHR = waist hip ratio, WTR = waist to thigh ratio; NW = normal weight, OW = over weight, OB = obese

7.3.2. Comparison of selected physiological parameters among three body weight categories of boys

Comparison of selected physiological parameters of three body weight categories has been presented in Table 7.2.

One way ANOVA was performed to make an overall comparison of the selected physiological parameters among three body weight categories. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories. The results from the Table 7.2 show a significant variation (p<0.01) of PFI and

SBP among three body weight categories. The Scheffe's multiple comparisons post hoc analysis showed (p<0.05) significant difference of selected physiological parameters in each pairs of categories. It is noted from the Table 7.2 that resting SBP and resting respiratory rate differed significantly (p<0.05) among the three body weight categories of boys.

Table 7.2. Comparison of selected physiological parameters among three body weight categories of boys (number of normal weight boys = 125, number of overweight boys = 68, number of obese boys = 40)

Categories	PFI score	RSBP (mmHg)	RDBP (mmHg)	RPR(bpm)	RRR(cpm)
NW (a)	50.61 ± 8.06	104.02 ± 7.32	62.07 ± 7.18	86.68 ± 15.39	18.29 ± 3.46
OW (b)	40.58 ± 5.49	110.45 ± 6.64	66.30 ± 7.82	90.52 ± 15.41	19.01 ± 3.50
OB (c)	36.87 ± 3.32	114.42 ± 9.24	72.45 ± 8.60	93.9 ± 14.58	20.35 ± 3.97
Level of significance	**(ab)(ac) (bc)	** (ab)(ac)(bc)	* (ab)(ac)(bc)	*(ac)	* (ab)(ac)(bc)
F values	86.01	37.14	29.25	3.83	5.84

Values are Mean ± SD

One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected physiological parameters among three body weight categories in 11 - < 13 years age group (* p < 0.05, ** p < 0.01, ns = not significant). Sceffe's multiple comparison tests were performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly (p < 0.05) differed from 'b', (ac) indicates 'a' significantly (p < 0.05) differed from 'c', (bc) indicates 'b' significantly (p < 0.05) differed from 'c'. PFI = physical fitness index RSBP = resting systolic blood pressure, RDBP = resting diastolic blood pressure; RPR = resting pulse rate, RRR = resting respiratory rate, NW = normal weight, OW = over weight, OB = obese

7.3.3. Range of PFI score of three body weight categories of in 11 - <13 years boys

Table 7.3 shows that in normal weight category the mean PFI was 50.61 (range 38.29 to 64.74). On the other hand, in overweight category the mean PFI was 40.58 (range 34 to 58.44). In contrary, in obese category the mean PFI was 36.87 (range 32.49 to 42.58).

7.3.4. Comparison of percentile values of PFI score among three body weight categories of boys

Comparison of 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles of PFI scores among three weight categories are presented in Table 7.4.

Table 7.3. Mean, standard deviation (SD), median and range of PFI scores of three body weight categories of boys

Categories	Parameter	Mean	SD	Median	Minimum	Maximum
Normal weight	PFI	50.61	8.06	50.27	38.29	64.74
Overweight		40.58	5.49	39.48	34.0	58.44
Obese		36.87	3.32	36.66	32.49	42.58

Table 7.4. Comparison of selected percentiles values of PFI among three body weight categories of boys

Categories	Mean	SD	Percentile						
			5th	10th	25th	50th	75th	90th	95th
Normal weight	50.61	8.06	40.00	40.54	42.85	50.27	55.90	62.5	63.38
Overweight	40.58	5.49	34.61	35.15	36.29	39.48	43.17	47.61	52.63
Obese	36.87	3.32	32.66	32.96	33.51	36.66	39.73	41.66	42.35

It is observed from the Table 7.4 that the 5th, 10th, 25th, 75th, 90th and 95th percentile values of PFI were higher in normal weight category than in over weight and obese category. In contrary, the lowest (5th) to highest (95th) percentiles values of PFI were higher in overweight category than in obese category.

7.3.5. Determination of association BMI and body fat% with physical fitness index (PFI)

Pearson's product-moment correlation coefficients of BMI and body fat% with physical fitness index (PFI) were presented in Table 7.5.

Correlation analysis demonstrated that BMI had significant (p<0.001) and negative correlation with physical fitness index (PFI). In contrary, result also showed (Table 7.5) that body fat% had significant negative correlation (p<0.001) with physical fitness index (PFI).

Table 7.5. Pearson's product moment correlation coefficient of BMI and % of Fat with PFI

Variable	BMI(kg/m^2) (N = 233)			Body fat% (N = 233)		
	r	95% CI	Level of significance	r	95% CI	Level of significance
PFI	- 0.632	- 0.704, - 0.548	P< 0.001	- 0.599	- 0.675, - 0.510	P< 0.001
ns = not significance, 95 % CI = 95% confidence intervals						

BMI = body mass index

Table 7.6. Pearson's product moment correlation coefficient of WHR and WTR with PFI

Variable	WHR (N = 233)			WTR (N = 233)		
	r	95% CI	Level of significance	r	95% CI	Level of significance
PFI	- 0.621	- 0.694, - 0.535	p< 0.001	- 0.411	- 0.512, - 0.298	p< 0.001
ns = not significance, 95 % CI = 95% confidence intervals						

WHR = waist hip ratio; WTR = waist thigh ratio

7.3.6. Determination of association of WHR and body WTR with physical fitness index (PFI)

Pearson's product-moment correlation coefficients of WHR and WTR with physical fitness index (PFI) were presented in Table 7.6.

Pearson's product-moment correlation coefficient analysis demonstrated that WHR had significant (p<0.001) and negative correlation with physical fitness index. On the other hand, result (Table 7.6) also showed that WTR had significant (p<0.001) and negative correlation with physical fitness index (PFI).

7.3.7. Multiple linear regression analysis

Multiple linear regression analysis was performed to see whether there were independent relationships of anthropometric obesity parameters (i.e., BMI, body fat%, WHR and WTR) with PFI and standard partial regression coefficients (β) are presented in support of that (Table 7.8).

Multiple regression analysis demonstrated that waist to hip ratio (WHR) had independent significant ($p<0.001$) negative impact on physical fitness index (PFI) when body mass index (BMI), body fat% and waist to thigh ratio were controlled. Hence, it appears from the present study that waist to hip ratio (WHR) is partly good detector for variability of physical fitness index (PFI) in these children. It is also observed from the Table7.8 that even after controlling the effects of body fat%, waist to hip ratio (WHR) and waist to thigh ratio (WTR), BMI had independent significant ($p<0.006$) and negative association with the physical fitness index (PFI).

Table 7.7. Multiple regression analysis of PFI on BMI, body fat%, WHR and WTR

Physical fitness index (PFI) is dependent variable									
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
BMI	98.85	-1.32	0.48	- 0.53	-2.79	p<0.006	43.96	p<0.001	0.43
Body fat%		0.09	0.23	0.13	0.75	ns			
WHR		-57.52	15.70	- 0.38	-3.66	p<0.001			
WTR		-13.25	6.30	0.15	-2.10	0.036			

BMI = body mass index, WHR = waist hip ratio, WTR = waist to thigh ratio.

7.4. Discussion

The results of the selected anthropometrics and physiological measurement of the school going Bengali boys (aged 11 to below 13 years) in three different district towns Bankura, Paschim Medinipur and Purba Medinipur of state of West Bengal, from this study showed that BMI, body fat%, waist hip ratio (WHR), waist to thigh ratio (WTR) and resting blood pressure (i.e., SBP and DBP), pulse rate, respiratory rate and PFI score significantly higher in obese and overweight boys than in normal weight boys. The present study reveals that BMI significantly ($p<0.001$) and negatively correlates with the PFI score. Moreover, multiple linear regression analysis reveals that BMI had independently associated with PFI score similar as the finding of **Das and Dhundasi (2001).**

It is evident from the study that body fat % significantly ($p<0.001$) and negatively correlated with the PFI score. **Gutin et al. (2004)** assessed body fat by dual energy x-ray absorptiometry (DXA) in youth and showed a negative association between body fat% and cardiorespiratory fitness in terms of PFI. In contrary, multiple regression analysis reveals that body fat% do not have any significant relation with PFI score, when BMI, WHR and WTR controlled, this findings well corroborate with previous finding in Bengali children and adolescent by **Mukherjee and Dhara (2014).** It is also evident from our study that central obesity marker WHR had significant ($p<0.001$) and negative correlation with PFI score. Our present finding also corroborate with the findings of **Ortega et al.** in **2010,** they observed that physical fitness index was negatively associated with waist circumference in Swedish and Spanish youth. On the other hand, **Winsley et al.** in **2006** showed that visceral obesity assessed by MRI was negatively associated with cardio-respiratory fitness in children.

In contrary, multiple analyses shows that even after controlling the effect of BMI, WTR and body fat%, WHR had strong negative impact on PFI score. Increased central adiposity may lower utilization of oxygen per unit of body mass or respiratory trouble may occur due to higher amount of fat deposition in the abdomen and chest cavity. This may restrict proper functioning of heart especially during physical activities or exercises

(Bandyopadhyay, 2012). Thus on the basis of the present study it may be said that lower score of PFI may result in higher values of BMI, body fat % and WHR which may be detrimental to cardio respiratory fitness. Increased cardio respiratory fitness (measured in terms of VO_2 Max) had been found to lower BMI, body fat% and WHR **(Bandyopadhyay, 2012; Chikuji et al., 1999)**. In light of these earlier studies and results of the present study it may be said that obesity parameters has a negative effect on cardio-respiratory fitness in terms of physical fitness index (PFI).

7.5. Conclusion

The mean value of physical fitness index (PFI) was found to be higher in normal weight boys than in overweight and obese boys. Resting pulse rate, respiratory rate and blood pressure (SBP & DBP) were higher in overweight and obese children compared to normal children**.** The findings documented herein found significant negative association of obesity parameters (i.e., BMI, body fat%, WHR and WTR) with PFI. This indicates a lower level of cardiovascular efficiency in overweight and obese boys compared to normal weight boys. The results of this study emphasizes the need for early identification of the risk factors leading to excessive BMI, body fat% and initiation of preventive measures in order to prevent the deterioration of cardiovascular performance in 11 - <13 years old school going Bengali boys.

Childhood Obesity & Selected Blood Parameters

Chapter VIII

8.1. Introduction

Childhood overweight and obesity has significant adverse effects on the present and future health of children. Among the most common medical conditions associated with childhood obesity are heart disease, high blood pressure, asthma, type 2 diabetes, gallstones, liver problems, menstrual problems, trouble sleeping, obstructive sleep apnea, certain kinds of cancers and metabolic syndrome **(Li et al., 2004; Kuczmarski et al., 2000).** Many overweight and obese children and adolescents have high cholesterol and / or blood pressure values which are risk factors for coronary artery disease (CAD) and stroke. The **Bogalusa Heart Study (1972 to 2016)** has shown that overweight and obese school children were 2.4 to 7.1 times more likely to have elevated total cholesterol (TC), low density lipoprotein cholesterol (LDLC) and triglycerides. In addition, children or adolescents who are not overweight but instead have a family history of premature cardiovascular disease or have at least one parent with high blood cholesterol are at increased risk of having high blood cholesterol and accelerated atherosclerotic processes **(Health Risks of Overweight Children UCSF, 2014)**.

Pathology studies have shown that atherosclerosis begins in childhood and that the extent of atherosclerotic change in children and young adults can be correlated with the presence of the same risk factors identified in adults **(Berenson et al., 1998; Newman et al., 1991)**. Risk factors during childhood such as elevated cholesterol and increased BMI have been shown to increase the risk of coronary artery disease (CAD) and stroke in adulthood, as well as cause early signs of atherosclerosis including coronary artery calcification, reduced arterial distensibility, and increased carotid intimal-medial thickness **(Baker et al., 2007; Davis et al., 2001; Mahoney et al., 1996; Whincup et al., 2005)**. In general, researchers have shown that children who are overweight or obese are more likely to present with an abnormal lipid profile and have a greater number of coronary artery disease risk factors

(**Smoak et al., 1987).** On the other hand, hyperuricemi**a** is the major and primary risk factor of symptomatic gout (**Singh et al., 2011)**, the clinical significance of which has been identified as the development of various co- morbidities including gout, metabolic syndrome (hyperglycaemia), coronary artery disease (CAD) and type 2 diabetes (**Rho et al., 2005; Mellen et al., 2006; Zhu et al., 2012),** despite its major antioxidant property. Hyperuricemia also reflects insulin resistance in some studies **(Krishnan et al., 2012; Yoo et al., 2011),** which is the basic pathophysiology of type 2 diabetes. Metabolic syndrome represents a cluster of physiological and anthropometric abnormalities characterized by abnormally elevated glucose level, obesity, hypertension, elevated triglycerides and higher level of low density lipoprotein cholesterol (LDLC) and lower level of high density lipoprotein cholesterol (HDLC), **(Yamaoka et al., 2010)**. These abnormalities are also characteristic of persons with hyperinsulinemia and hyperuricemia **(Tesauro et al., 2011).**

Few studies correlating obesity indices with coronary artery disease risk factors have been conducted among children in developing countries, particularly in India. For the development of more efficient clinical prevention and intervention programs, studies targeted at this population are necessary. The objective of the present study was to evaluate the association of obesity and physiological parameters with coronary artery disease risk factors (TC, TG, HDLC, LDLC, and TC: HDLC, blood glucose and uric acid).

8.2. Materials and methods

The present study was carried-out in 1036 healthy school going Bengali boys aged between 5 to 12 years. Among 1036 boys, only 442 boys did agree to participate for volunteered study.

On the basis of BMI-age-boys Z-scores (normal weight: - 2SD > BMI Z score ≤ + 1SD, overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD), boys were categorised in three sub-divisions such Normal weight, Overweight and Obese **(WHO, 2007)**. All the selected anthropometric (i.e., height, weight, BMI, WHR and WTR), physiological (i.e., SBP, DBP, resting pulse rate, resting respiratory rate) and biochemical parameters were determined by standard procedures which have been elaborately discussed in Chapter III.

8.3. Results

8.3.1. Range of selected biochemical parameters of three body weight categories in 5 - <7 years age groups

Table 8.1 demonstrated that in normal weight boys of 5 - <7 years age mean values including range of blood parameters were as follows i.e., mean total cholesterol (TC) of normal weight categories was 137.09 $mg.dl^{-1}$ (range 94.66 to 212.24 $mg.dl^{-1}$), triglycerides (TG) 80.68 $mg.dl^{-1}$ (range 30.27 to 145.17 $mg.dl^{-1}$), high density lipoprotein cholesterol -(HDLC) 35.92 $mg.dl^{-1}$ (range 18.33 to 76.35 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 85.03 $mg.dl^{-1}$ (range 52.32 to 125.97 $mg.dl^{-1}$), TC:HDLC 4.10 (range 2.13 to 6.20), blood glucose 69.62 $mg.dl^{-1}$ (range 52.32 to 125.97 $mg.dl^{-1}$), uric acid 3.36 $mg.dl^{-1}$ (range 1.98 to 4.75 $mg.dl^{-1}$).

On the other hand, in overweight boys of 5 - <7 years age mean values including range of blood parameters were as follows i.e., mean total cholesterol (TC) of overweight categories was 140.25 $mg.dl^{-1}$ (range 99.93 to 225.35 $mg.dl^{-1}$), triglycerides (TG) 84.97 $mg.dl^{-1}$ (range 35.17 to 150.78 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 34.34 $mg.dl^{-1}$ (range 16.64 to 64.4 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 88.91 $mg.dl^{-1}$ (range 45.85 to 166.45 $mg.dl^{-1}$), TC:HDLC 4.49 (range 2.19 to 8.15), blood glucose 71.42 mg.dl^{-1} (range 56.51to 102.4 mg.dl^{-1}), uric acid 3.20 mg.dl^{-1} (range 2.2 to 4.45 mg.dl^{-1}).

Table 8.1. Mean, standard deviation (SD), median and range of selected biochemical parameters of three body weight categories (Total number boys = 106, number of normal weight = 40, number of overweight boys = 34, number of obese boys = 32) in 5 - < 7years age groups

Categories	Biochemical parameters	Mean	SD	Median	Range		*Pediatric Range	
					Minimum	Maximum	Minimum	Maximum
NW	TC (mg.dl^{-1})	137.09	27.45	130.24	94.66	212.24	108.00	187.00
OW		140.25	34.38	132.5	99.93	225.35		
OB		158.16	36.64	169.32	104.22	234.50		
NW	TG (mg.dl^{-1})	80.68	32.99	78.86	30.27	145.17	32.00	116.00
OW		84.97	29.69	84.46	35.16	150.78		
OB		93.29	26.69	90.60	54.40	160.50		
NW	HDLC (mg.dl^{-1})	35.92	14.29	31.16	18.33	76.35	35.00	82.00
OW		34.34	12.56	32.00	16.64	64.40		
OB		32.37	8.96	30.55	18.60	56.70		
NW	LDLC (mg.dl^{-1})	85.03	19.34	82.63	52.32	125.97	63.00	140.00
OW		88.91	29.12	85.30	45.85	166.45		
OB		107.13	31.33	111.97	56.09	185.48		
NW	TC:HDLC	4.10	0.99	4.19	2.13	6.20	-	-
OW		4.49	1.53	4.46	2.19	8.15		
OB		5.07	1.24	5.02	3.08	8.84		
NW	Blood glucose (mg.dl^{-1})	69.62	11.65	70.06	49.51	98.22	60.00	110.00
OW		71.42	11.65	68.6	56.51	102.40		
OB		76.20	13.24	72.7	61.77	106.50		
NW	Uric acid (mg.dl^{-1})	3.36	0.71	3.29	1.98	4.75	2.00	7.00
OW		3.20	0.72	3.30	2.20	4.45		
OB		3.10	0.74	3.03	2.20	4.53		

***(Soldin et al., 1999)**

Additionally , in obese category mean values including ranges of blood parameters were as follows i.e., TC was 158.16 mg.dl^{-1} (range 104.22 to 234.5 mg.dl^{-1}), triglycerides (TG) 93.29 mg.dl^{-1} (range 54.4 to 160.5 mg.dl^{-1}), high density lipoprotein cholesterol (HDLC) 32.37 mg.dl^{-1} (range 18.6 to 56.7 mg.dl^{-1}), low density lipoprotein cholesterol (LDLC) 107.13 mg.dl^{-1} (range 56.09 to 185.48 mg.dl^{-1}), TC: HDLC 5.07 (range 3.08 to 8.84), blood glucose 76.20 mg.dl^{-1} (range 61.77 to 106.5 mg.dl^{-1}), and uric acid 3.10 mg.dl^{-1} (range 2.2 to 4.53 mg.dl^{-1}).

Table 8.2. Mean, standard deviation (SD), median and range of selected biochemical parameters of three body weight categories (Total number of boys = 108, number of normal weight boys = 43, number of overweight boys = 34, number of obese boys = 31) in 7 - < 9 years age groups

Categories	Biochemical parameters	Mean	SD	Median	Range		*Pediatric Range	
					Minimum	Maximum	Minimum	Maximum
NW	TC ($mg.dl^{-1}$)	144.23	24.34	140.72	105.72	218.49	112.00	247.00
OW		163.91	42.13	146.3	120.44	255.43		
OB		163.00	31.43	167.70	120.40	239.40		
NW	TG ($mg.dl^{-1}$)	77.41	32.60	73.99	36.92	178.00	28.00	129.00
OW		94.14	33.62	86.40	43.40	163.30		
OB		108.46	28.48	104.00	56.50	175.50		
NW	HDLC ($mg.dl^{-1}$)	39.01	13.60	34.5	22.93	79.70	35.00	82.00
OW		35.09	9.92	34.63	17.88	56.60		
OB		33.44	10.52	30.44	17.66	58.32		
NW	LDLC ($mg.dl^{-1}$)	89.74	19.92	86.27	50.22	139.49	63.00	140.00
OW		109.99	38.27	102.69	47.30	201.82		
OB		107.86	24.04	103.54	78.53	171.90		
NW	TC:HDLC	3.95	0.97	3.87	2.35	6.62	-	-
OW		4.93	1.46	5.22	2.44	7.71		
OB		5.17	1.33	5.05	3.35	8.19		
NW	Blood glucose ($mg.dl^{-1}$)	72.89	11.21	74.68	54.17	104.4	60.00	110.00
OW		76.69	12.57	73.12	60.50	105.50		
OB		84.19	14.45	82.34	65.45	108.44		
NW	Uric acid ($mg.dl^{-1}$)	3.47	1.31	3.03	2.12	7.10	2.00	7.00
OW		3.83	1.39	3.45	2.30	7.20		
OB		4.23	1.32	3.84	2.80	7.40		

***(Soldin et al., 1999)**

Table 8.1 demonstrates that the maximum values of total cholesterol (TC) and triglycerides (TG) of three body weight categories were found to be greater than recommended paediatric range **(Soldin et al., 1999)**. On the other hand, a maximum value of low density lipoprotein cholesterol (LDLC) was found to be higher than upper limit of recommended range in overweight and obese categories **(Soldin et al., 1999)**. It is also evident from Table 8.1 that the minimum value of HDLC was found to be lower than the lower limit of recommended range in three weight categories.

8.3.2. Range of selected biochemical parameters of three body weights categories in 7 - <9 years age groups

Table 8.2 demonstrated that normal weight boys of 7 - < 9 years age mean values including range of blood parameters were as follows i.e., mean total cholesterol (TC) of normal weight categories was 144.23 $mg.dl^{-1}$ (range 105.72 to 218.49 $mg.dl^{-1}$), triglycerides (TG) 77.14 $mg.dl^{-1}$ (range 36.92 to 178 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 39.01 $mg.dl^{-1}$ (range 22.93 to 79.7 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) $mg.dl^{-1}$ 89.74 (range 50.22 to 139.49 $mg.dl^{-1}$), TC:HDLC 3.95 (range 2.35 to 6.62), blood glucose 72.89 $mg.dl^{-1}$ (range 54.17 to 105.5 $mg.dl^{-1}$), uric acid 3.47 $mg.dl^{-1}$ (range 2.12 to 7.1 $mg.dl^{-1}$). On the other hand, in overweight boys of 7 - < 9 years age mean values including ranges of blood parameters were as follows i.e., mean total cholesterol (TC) of overweight categories was 163.91 $mg.dl^{-1}$ (range 120.44 to 255.43 $mg.dl^{-1}$), triglycerides (TG) 94.14 $mg.dl^{-1}$ (range 43.4 to 163.3 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 35.09 $mg.dl^{-1}$ (range 17.88 to 56.6 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 109.99 $mg.dl^{-1}$ (range 47.3 to 201.82 $mg.dl^{-1}$), TC: HDLC 4.93 (range 2.44 to 7.71), blood glucose 76.69 $mg.dl^{-1}$ (range 60.5 to 105.5 $mg.dl^{-1}$), and uric acid 3.83 $mg.dl^{-1}$ (range 2.3 to 7.2 $mg.dl^{-1}$).

Moreover, in obese category mean values including ranges of blood parameters were as follows i.e., total cholesterol (TC) 163 $mg.dl^{-1}$ (range 120.4 to 239.4 $mg.dl^{-1}$), triglycerides (TG) 108.46 $mg.dl^{-1}$ (range 56.5 to175.5$mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 33.44 $mg.dl^{-1}$ (range 17.66 to 58.32 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 107.86 $mg.dl^{-1}$ (range 78.53 to 171.9 $mg.dl^{-1}$), TC: HDLC 5.17 (range 3.35 to 8.19), blood glucose 84.19 $mg.dl^{-1}$ (range 65.45 to 108.44 $mg.dl^{-1}$), and uric acid 4.23 $mg.dl^{-1}$ (range 2.8 to 7.4 $mg.dl^{-1}$).

Table 8.3. Mean, standard deviation (SD), median and range of selected biochemical parameters of three body weight categories (Total number of boys = 110, number of normal weight boys = 40, number of overweight boys = 37, number of obese boys = 33) in 9 - <11 years age groups

Categories	Biochemical Parameters	Mean	SD	Median	Range		*Pediatric Range	
					Minimum	Maximum	Minimum	Maximum
NW	TC ($mg.dl^{-1}$)	155.18	28.88	145.05	120.98	219.45	112.00	247.00
OW		175.77	33.80	167.64	135.60	254.50		
OB		170.19	34.13	159.77	130.45	240.45		
NW	TG ($mg.dl^{-1}$)	82.95	33.62	85.02	27.66	142.98	28.00	137.00
OW		99.79	33.38	94.56	45.67	164.55		
OB		111.54	39.60	100.16	55.78	175.50		
NW	HDLC ($mg.dl^{-1}$)	38.47	11.57	36.85	25.33	79.66	36.00	84.00
OW		36.15	10.97	34.44	20.45	67.75		
OB		32.70	8.36	30.43	20.32	50.66		
NW	LDLC ($mg.dl^{-1}$)	100.11	22.80	93.10	69.97	171.72	64.00	140.00
OW		119.65	27.48	116.02	74.90	178.86		
OB		115.17	22.46	110.66	84.03	156.65		
NW	TC:HDLC	4.22	0.99	4.07	2.40	6.99	-	-
OW		5.16	1.34	4.80	2.40	7.89		
OB		5.34	0.93	5.25	3.74	7.17		
NW	Blood glucose ($mg.dl^{-1}$)	75.39	13.74	72.65	56.37	105.50	60.00	110.00
OW		85.01	15.71	80.4	64.55	115.56		
OB		88.31	16.90	82.54	68.70	118.60		
NW	Uric acid ($mg.dl^{-1}$)	4.01	1.29	3.57	2.76	7.50	2.00	7.00
OW		4.45	1.22	4.21	2.87	7.80		
OB		4.80	1.35	4.37	3.26	7.90		

***(Soldin et al., 1999)**

On the other hand, maximum values of total cholesterol (TC) and low density lipoprotein cholesterol (LDLC) was found to be higher than upper limit of recommended pediatric range in overweight and obese categories **(Soldin et al., 1999)**. It is also evident from the Table 8.2 that the higher value of triglyceride was found to be higher than normal values of recommended range in three body weight categories. In contrary, maximum values of blood glucose and uric acid level were higher than normal upper limit of recommended range in three body weight categories **(Soldin et al., 1999).**

8.3.3. Range of selected biochemical parameters of three body weights categories in 9 - < 11 years age groups

It is noted from the Table 8.3 that in normal weight boys of 9 - < 11 years age groups the mean values including ranges of blood lipid parameters were as follows i.e., total cholesterol (TC) 155.18 mg.dl^{-1} (range 120.98 to 219.45 mg.dl^{-1}), triglycerides (TG) 82.95 mg.dl^{-1} (range 27.66 to 142.98 mg.dl^{-1}), high density lipoprotein cholesterol (HDLC) 38.47 mg.dl^{-1} (range 25.33 to 79.66 mg.dl^{-1}), low density lipoprotein cholesterol (LDLC) mg.dl^{-1} 100.11 (range 69.97 to 171.72 mg.dl^{-1}), TC:HDLC 4.22 (range 2.40 to 6.99), blood glucose 75.39 mg.dl^{-1} (range 56.37 to 105.5 mg.dl^{-1}), uric acid 4.01 mg.dl^{-1} (range 2.76 to 7.5 mg.dl^{-1}).

In contrary, in overweight boys of 9 - < 11 years age groups the mean values including ranges of blood lipid parameters were as follows i.e., total cholesterol 175.77 mg.dl^{-1} (range 135.6 to 254.5mg.dl^{-1}), triglycerides (TG) 99.79 mg.dl^{-1} (range 45.67 to 164.55 mg.dl^{-1}), high density lipoprotein cholesterol (HDLC) 36.15 mg.dl^{-1} (range 20.45 to 67.75 mg.dl^{-1}), low density lipoprotein cholesterol (LDLC) 119.65 mg.dl^{-1} (range 74.90 to 178.86 mg.dl^{-1}), TC: HDLC 5.16 (range 2.40 to 7.89), blood glucose 85.01 mg.dl^{-1} (range 64.55 to 115.56 mg.dl^{-1}), and uric acid 4.45 mg.dl^{-1} (range 3.26 to 7.8 mg.dl^{-1}).

Additionally, in obese boys mean values including ranges of blood lipid parameters were as follows i.e., total cholesterol (TC) 170.19 mg.dl^{-1} (range 130.45 to 240.45 mg.dl^{-1}), triglycerides (TG) 111.54 mg.dl^{-1} (range 55.78 to 175.5 mg.dl^{-1}), high density lipoprotein cholesterol (HDLC) 32.70 mg.dl^{-1} (range 20.32 to 50.66 mg.dl^{-1}), low density lipoprotein cholesterol (LDLC) 115.17 mg.dl^{-1} (range 84.03 to 156.65 mg.dl^{-1}), TC: HDLC 5.34 (range 3.74 to 7.17), blood glucose 88.31 mg.dl^{-1} (range 68.7 to 118.6 mg.dl^{-1}), and uric acid 4.80 mg.dl^{-1} (range 3.26 to 7.9 mg.dl^{-1}).

Table 8.4. Mean, standard deviation (SD), median and range of selected biochemical parameters of three body weight categories (Total number of boys = 118, number of normal weight boys = 42, number of overweight boys = 40, number of obese boys = 36) in 11 - <13 years age groups

Categories	Biochemical parameters	Mean	SD	Median	Range		*Paediatric Range	
					Minimum	Maximum	Minimum	Maximum
NW	TC ($mg.dl^{-1}$)	157.13	28.20	147.49	127.29	232.55	125	244
OW		181.66	29.60	184.99	132.39	241.34		
OB		174.45	33.79	175.70	127.56	245.54		
NW	TG ($mg.dl^{-1}$)	90.45	34.84	95.53	28.45	158.67	24	145
OW		95.20	27.50	101.06	30.54	135.54		
OB		117.84	31.88	121.15	56.54	172.65		
NW	HDLC ($mg.dl^{-1}$)	40.06	14.08	36.47	24.56	75.56	36	84
OW		34.33	6.57	33.05	24.78	47.4		
OB		34.18	10.19	31.09	18.67	55		
NW	LDLC ($mg.dl^{-1}$)	98.98	15.20	95.11	69.72	135.6	64	140
OW		128.29	23.49	127.23	82.96	173.33		
OB		116.70	27.03	113.61	76.12	177.41		
NW	TC:HDLC	4.13	0.77	4.23	2.30	5.58	-	-
OW		5.36	0.74	5.41	3.72	7.13		
OB		5.40	1.39	5.27	3.22	7.99		
NW	Blood glucose ($mg.dl^{-1}$)	75.63	13.71	73.79	56.5	106.45	60	110
OW		86.61	15.48	81.63	65.59	119.54		
OB		94.33	17.54	88.39	74.74	125.54		
NW	Uric acid ($mg.dl^{-1}$)	4.21	1.35	4.00	2.55	7.4	2	7
OW		4.70	1.77	3.79	2.76	8.4		
OB		5.11	1.20	4.78	3.78	8.4		

***(Soldin et al., 1999)**

Table 8.3 demonstrates that the maximum values of total cholesterol (TC) of overweight categories were found to be greater than the normal upper limit of recommended pediatric range **(Soldin et al., 1999)**. On the hand, maximum range of triglycerides (TG), low density lipoprotein cholesterol (LDLC) and blood glucose of overweight and obese boys was found to be higher than normal upper limit of recommended range **(Soldin et al., 1999)**. Moreover, maximum values of uric acid of three body weight categories were found to be higher than normal upper limit of recommended range.

8.3.4. Range of selected biochemical parameters of three body weights categories in 11 - < 13 years age groups

Table 8.4 shows that in normal weight boys of 11 - < 3 years of age the mean values including ranges of blood parameters were as follows i.e., total cholesterol (TC) 157.13 $mg.dl^{-1}$ (range 127.29 to 232.55 $mg.dl^{-1}$), triglycerides (TG) 90.45 $mg.dl^{-1}$ (range 28.45 to 158.67 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 40.06 $mg.dl^{-1}$ (range 24.56 to 75.56 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 98.88 $mg.dl^{-1}$ (range 69.72 to 135.6 $mg.dl^{-1}$), TC:HDLC 4.13 (range 2.30 to 5.58), blood glucose 75.63 $mg.dl^{-1}$ (range 56.5 to 106.45 $mg.dl^{-1}$), uric acid 4.21 $mg.dl^{-1}$ (range 2.55 to 7.4 $mg.dl^{-1}$).

On the other hand, in overweight boys of 11- < 13 years of age the mean values including blood parameters were as follows i.e., total cholesterol (TC) 181.66 $mg.dl^{-1}$ (range 132.39 to 241.34 $mg.dl^{-1}$), triglycerides (TG) 95.20 $mg.dl^{-1}$ (range 30.54 to 135.54 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 34.33 $mg.dl^{-1}$ (range 24.78 to 47.4 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 128.29 $mg.dl^{-1}$ (range 82.96 to 173.33 $mg.dl^{-1}$), TC:HDLC 5.36 (range 3.72 to 7.13), blood glucose 86.61 $mg.dl^{-1}$ (range 65.59 to 119.54 $mg.dl^{-1}$), uric acid 4.70 $mg.dl^{-1}$ (range 2.76 to 8.4 $mg.dl^{-1}$).

Moreover, in obese boys mean values including range of blood lipid parameters were as follows i.e., total cholesterol (TC) of obese categories was 174.45 $mg.dl^{-1}$ (range 127.56 to 245.54 $mg.dl^{-1}$), triglycerides (TG) 117.84 $mg.dl^{-1}$ (range 56.54 to 172.65 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 34.18 $mg.dl^{-1}$ (range 18.67 to 55 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) $mg.dl^{-1}$ 116.70 (range 76.12 to 177.41 $mg.dl^{-1}$), TC: HDLC 5.40 (range 3.22 to 7.99), blood glucose 94.33 $mg.dl^{-1}$ (range 74.74 to 125.54 $mg.dl^{-1}$), and uric acid 5.11 $mg.dl^{-1}$ (range 3.78 to 8.4 $mg.dl^{-1}$).

It is also observed from Table 8.4 that the maximum values of total cholesterol (TC), low density lipoprotein cholesterol (LDLC), blood glucose and uric acid among overweight and obese categories were found to be greater than the normal upper limit of recommended pediatric range **(Soldin et al., 1999)**. On the hand, maximum values of triglycerides (TG) of normal weight and obese boys were found to be higher than normal upper limit of recommended range **(Soldin et al., 1999)**. Moreover, values of uric acid of three body weight categories were found to be higher than normal upper limit of recommended range.

8.3.5. Comparison of selected biochemical parameters among three body weight categories in four different age groups of boys

Comparisons of selected biochemical parameters among three body categories in each of the four age groups of boys are presented in Table 8.5. One way ANOVA was performed to make an overall comparison of the selected biochemical parameters among three body weight categories in each of the four age groups. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group. It is observed from the Table 8.5 that there was no significant difference in high density lipoprotein cholesterol (HDLC) among three body weight categories in all age group. On the other hand, low density lipoprotein cholesterol (LDLC), TC: HDLC were significantly ($p<0.05$) higher in overweight and obese boys compared to normal weight categories in all age groups. Moreover in post hoc multiple comparison tests showed that total cholesterol (TC) significantly higher in overweight boys compared to normal weight categories in all age groups except 5 – < 7 years age groups, where significant ($p<0.05$) difference was only observed between normal weight and obese categories. In contrary, triglyceride, blood glucose and uric acid differed significantly ($p<0.05$) among three body weight categories in 7 – < 9 years, 9 - <11 years and 11 – < 13 years age groups.

Table 8.5. Comparison of selected biochemical parameters among three body weight categories in four different age groups of boys

Age groups (years)	Category	TC ($mg.dl^{-1}$)	TG ($mg.dl^{-1}$)	HDLC ($mg.dl^{-1}$)	LDLC ($mg.dl^{-1}$)	TC:HDLC	Blood glucose ($mg.dl^{-1}$)	Uric acid ($mg.dl^{-1}$)
5 - < 7 N =106)	NW (a) (n = 40)	137.09±27.45	80.68±32.99	35.92±14.29	85.03±19.34	4.10±0.99	69.62±11.65	3.36±0.71
	OW (b) (n = 34)	140.25±34.38	84.97±29.69	34.34±12.56	88.91±29.12	4.49±1.53	71.42±11.65	3.20±0.72
	OB (c) (n=32)	158.16 ±36.64	93.29±26.29	32.37±8.96	107.13±31.33	5.07±1.24	76.20±13.24	3.10±0.74
F value		4.11	1.57	0.73	6.69	5.25	2.69	1.21
Level of significance		*(ac)	ns	ns	*(ac)(bc)	*(ac)	ns	ns
7 - < 9 (N =108)	NW (a) (n = 43)	144.23±24.34	77.41±32.60	39.01±13.60	89.74±19.92	3.95 ±0.97	72.89±11.21	3.47±1.31
	OW (b) (n = 34)	163.91±42.13	94.14±33.62	35.09±9.92	109.99±38.27	4.93±1.46	76.69±12.57	3.83±1.39
	OB (c) (n=31)	163.00±31.43	108.46±28.48	33.44±10.52	107.86±24.04	5.17±1.33	84.19±14.45	4.23±1.32
F value		4.45	8.73	2.25	6.14	10.29	7.26	2.86
Level of significance		*(ab)	*(ac)	ns	*(ab)(ac)	*(ab)(ac)	*(ac)	ns
9 - < 11 (N =110)	NW (a) (n = 40)	155.18±28.88	82.95±33.62	38.47±11.57	100.11±22.80	4.22±0.99	75.39±13.74	4.04±1.29
	OW (b) (n=37)	175.77±33.80	99.79 ±33.68	36.15±10.97	119.65±27.48	5.16±1.34	85.01±15.71	4.45±1.22
	OB (c) (n=33)	170.19±34.13	111.54±39.60	32.70 ±8.36	115.17±22.46	5.34±0.93	88.31±16.90	4.80±1.35
F value		4.21	5.96	2.68	6.77	10.85	7.04	3.19
Level of significance		*(ab)	*(ac)	ns	*(ab)(ac)	*(ab)(ac)	*(ab)(ac)	*(ac)
11 - < 12 (N =118)	NW (a) (n=42)	157.13±28.20	90.45±34.84	40.06±14.08	98.98±15.20	4.13±0.77	75.63±13.71	4.21±1.35
	OW (b) (n = 40)	181.66±29.60	95.20±27.50	34.33±6.57	128.29±23.49	5.36±0.74	86.61±15.48	4.70±1.77
	OB (c) (n = 36)	174.45±33.79	117.84±31.88	34.18±10.19	116.70±27.03	5.40±1.39	94.33±17.54	5.11±1.20
F value		7.02	8.10	3.89	18.17	21.07	14.28	3.60
Level of significance		*(ab)(ac)	*(ab)(ac)	ns	*(ab)(ac)	*(ab)(ac)	*(ab)(ac)	*(ac)

Values are Mean ± SD

'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight category. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected biochemical parameters among three body weight categories in each age group (* $p < 0.05$, ns = not significant). Sceffe's multiple comparison test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'. TC = total cholesterol, TG = triglycerides, HDLC = high density lipoprotein cholesterol, LDLC = low density lipoprotein cholesterol, TC: HDLC = total cholesterol to high density lipoprotein cholesterol ratio; NW = normal weight, OW = overweight, OB = obese

Table 8.6. Comparison of selected anthropometric obesity parameters among three body weight categories in four different age groups of boys

Age groups (years)	Categ,	Height (cm)	Body weight (Kg)	BMI (Kg/m^2)	WHR	WTR	Body fat%
5 – < 7 (N =106)	NW (a) (n = 40)	109.88±1.97	17.7±1.15	14.72±0.64	0.919±0.023	1.746±0.096	11.42±1.32
	OW (b) (n = 34)	110.71±2.15	21.66±1.04	17.66±0.41	0.998±0.026	1.777±0.092	16.97±2.16
	OB (c) (n= 32)	112.99±3.88	25.09±1.70	20.28±0.88	1.010±0.021	1.811±0.104	21.47±3.50
F values		13.93	339.44	624.05	139.06	3.94	155.73
Level of significance		*(ac) (bc)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	*(ac)	**(ab)(bc)(ac)
7 - < 9 (N =108)	NW (a) (n = 43)	123.07±1.98	23.65±1.31	15.61±0.65	0.900±0.027	1.697±0.079	13.44±1.63
	OW (b) (n = 34)	123.44±1.53	27.82±1.14	18.25±0.54	0.989± 0.027	1.766±0.137	19.41±1.73
	OB (c) (n = 31)	124.93±2.66	32.81±2.22	21.0±0.90	0.997±0.025	1.795±0.091	23.59±4.06
F values		7.52	301.56	528.77	153.21	8.86	144.20
Level of significance		*(ac) (bc)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	*(ab) (ac)	**(ab)(ac)(bc)
9 - < 11 (N =110)	NW (a) (n = 40)	133.68±1.70	29.14±2.03	16.29±0.90	0.872±0.018	1.617±0.081	13.61±2.48
	OW (b) (n = 37)	135.41±2.71	36.13±2.35	19.68 ±0.72	0.963±0.022	1.668±0.098	21.30±1.76
	OB (c) (n = 33)	135±2.65	41.73±3.66	22.85±1.18	0.992±0.021	1.778±0.124	25.20±2.62
F values		5.58	197.20	437.47	337.13	23.22	240.72
Level of significance		* (ab)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	* (ac) (bc)	**(ab)(ac)(bc)
11 - <13 (N =118)	NW (a) (n = 42)	144.48±1.56	33.55±1.21	16.07±0.62	0.868±0.025	1.579±0.041	13.04±2.40
	OW (b) (n = 40)	144.72±1.55	44.40±1.63	21.20±0.75	0.964±0.017	1.651±0.058	24.10±1.67
	OB (c) (n = 36)	146.55±2.80	52.93±5.30	24.59±1.65	0.981±0.021	1.756±0.068	27.16±3.17
F values		11.83	369.24	617.17	317.50	94.43	362.11
Level of significance		*(ac) (bc)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	**(ab)(ac)(bc)	*(ab)(ac)(bc)	**(ab)(ac)(bc)

Values are Mean ± SD

'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight category. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected anthropometric obesity parameters among three body weight categories in each age group (* $p < 0.05$, ** $p < 0.01$, ns = not significant). Sceffe's multiple comparisons test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'. BMI = body mass index, WHR = waist to hip ratio, WTR = waist to thigh ratio; Categ, = Category; NW = normal weight; OW = overweight; OB = obese

Table 8.7. Comparison of selected physiological parameters among three body weight categories in four different age groups boys

Age groups (years)	Category	Resting pulse rate (bpm)	Resting respiratory rate (cpm)	Blood pressure (mmHg)	
				SBP	DBP
5 - < 7 (N = 106)	NW (a) (n = 40)	98.8 ± 11.24	22.37 ± 2.95	89.45 ± 7.39	50.94 ± 5.76
	OW (b) (n =34)	103.5 ± 14.40	23.17 ± 3.74	98.44 ± 11.17	59.58 ± 9.96
	OB (c) (n = 32)	115.06 ± 12.48	25.90 ± 4.86	98.34 ± 98.43	59.5 ± 6.05
F value		15.03	7.87	14.60	9.45
Level of significance		*(ab)(bc)(ac)	*(ac)(bc)	*(ab)(ac)	*(ab)(ac)
7 - < 9 (N = 108)	NW (a) (n = 43)	97.88 ± 14.38	21.65 ± 3.04	95.65 ± 6.91	58.51 ± 7.58
	OW (b) (n = 34)	99.47 ± 13.71	22.14 ± 3.15	100.05 ± 6.11	61.38 ± 6.06
	OB (c) (n = 31)	107.19 ± 14.93	24.77 ± 4.01	103.41 ± 8.43	63.70 ± 7.98
F value		4.10	8.34	10.91	4.71
Level of significance		*(ac)(bc)	*(ac)(bc)	*(ab)(ac)(bc)	*(ab)(ac)(bc)
9 - < 11 (N = 110)	NW (a) (n = 40)	86.05 ± 12.27	19.72 ± 2.86	100.05 ± 7.37	60.3 ± 7.06
	OW (b) (n = 37)	96.64 ± 15.97	21.00 ± 3.97	103.45 ± 7.50	63.91 ± 7.19
	Obese (c) (n = 33)	101.84 ± 13.41	21.78 ± 3.73	107.93 ± 7.98	67.90 ± 7.56
F value		12.34	3.20	9.73	9.93
Level of significance		*(ab)(ac)(bc)	*(ab)(ac)	*(ab)(bc)(ac)	*(ab)(ac)(bc)
11 - < 13 (N = 118)	NW (a) (n = 42)	79.44 ± 12.08	18.21 ± 3.63	104.04 ± 7.59	62.76 ± 7.54
	OW (b) (n = 40)	89.77 ± 15.01	19.2 ± 3.37	110.82 ± 6.89	66.12 ± 8.52
	OB (c) (n = 36)	97.47 ± 13.04	20.41 ± 3.91	114.02 ± 9.02	71.72 ± 8.51
F value		17.77	3.55	16.71	11.72
Level of significance		*(ab)(ac)(bc)	*(ab)(ac)(bc)	*(ab)(ac)(bc)	*(ab)(ac)(bc)

Values are Mean ± SD

'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight category. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected physiological parameters among three body weight categories in each age group (* $p < 0.05$, ns = not significant). Sceffe's multiple comparisons test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'. BMI = body mass index, WHR = waist to hip ratio, WTR = waist to thigh ratio; NW = normal weight; OW = overweight; OB = obese

8.3.6. Comparison of selected anthropometric obesity parameters among three body weight categories in four different age groups of boys

Comparisons of selected anthropometric obesity parameters among three body weight categories in each of the four age groups of boys are presented in Table 8.6.

One way ANOVA was performed to make an overall comparison of the selected biochemical parameters among three body weight categories in each of the four age groups. Again, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group.

It is noted from the Table 8.6 that body weight, BMI, WHR and body fat% differed significantly ($p<0.01$) among the three body weight categories in all age groups. On the other hand, WTR significantly differed ($p<0.01$) among three body weight categories in all age groups except 5 – <7 years, where significant difference only observed between normal weight and obese categories. Moreover, in post hoc multiple comparison tests all pairs of body weight categories in the above mentioned parameters showed significant difference ($p<0.05$) except height where significant ($p<0.05$) difference was only observed in few cases among three body weight categories.

8.3.7. Comparison of selected physiological parameters among three body weight categories in four different age groups of boys

Comparisons of selected physiological parameters among three body categories in each of the four age groups of boys are presented in Table 8.7.

One way ANOVA was performed to make an overall comparison of the selected biochemical parameters among three body weight categories in each of the four age groups. Again, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group. The results of ANOVA showed a significant variation ($p<0.05$) of selected physiological parameters among three body weight categories. Sceffe's multiple comparison tests demonstrated that resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) differed significantly ($p<0.05$) in each pair of the three body weight categories of all age groups except between overweight and obese in 5 - < 7 and 7 - < 9 years age groups. On the other hand, resting pulse rate differed significantly among three body weight categories in all age groups except between overweight and normal weight categories in 11 - <13 years age groups. It is also observed from the Table 8.7 that respiratory rate differed significantly ($p<0.05$) between overweight and obese categories in 11 - <13 years age groups.

8.3.8. Comparison of selected biochemical parameters among four age groups in each body weight category of boys

Comparisons of selected biochemical parameters among four age groups in each of three body weight categories of boys are presented in Fig 8.1 to 8.7

In Fig 8.1 comparison of total cholesterol (TC) levels among four age groups in each of Normal weight, an Overweight and Obese category has been presented. It is observed from the Fig 8.1 that in obese category, no significant difference in total cholesterol (TC) was found among four age groups.

Fig 8.1 reveals that total cholesterol (TC) significantly ($p<0.05$) differed in between 5 - < 7 years and 11 - <13 years age groups in normal weight and overweight categories as observed through one way ANOVA. Post hoc Sceffe's multiple comparison tests also demonstrated that significant difference ($p<0.05$) of total cholesterol (TC) in between 5 - < 7 years and 11 - <13 years age groups in normal weight and overweight categories. Overall we found an increasing trend of total cholesterol (TC) with age in each three body weight categories of boys.

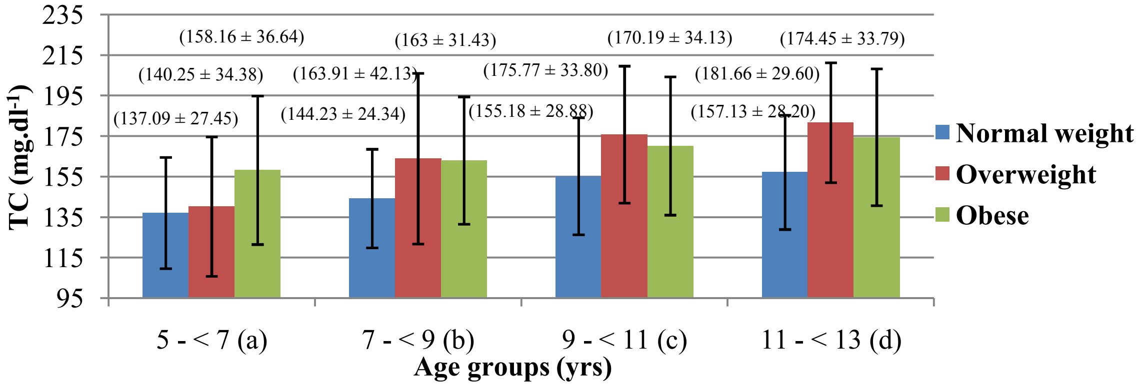
Comparison of triglycerides (TG) among four age groups in each of Normal weight, an Overweight and Obese category has been presented in Fig 8.2. The results of ANOVA showed no significant difference in triglycerides (TG) among four age groups in normal weight and overweight categories of boys. Moreover, Sceffe's multiple comparison tests demonstrated that significant difference ($p<0.05$) of triglycerides only in between 5 - < 7 years and 11 - <13 years age groups in obese categories. Overall we found an increasing trend of total cholesterol (TC) with age in obese categories of boys.

In Fig 8.3 comparison of high density lipoprotein cholesterol (HDLC) among four age groups in each body weight category has been presented. It is evident from the Fig 8.3 high density lipoprotein cholesterol (HDLC) was not significantly different among four age groups in each of three body weight categories of boys.

It is revealed from the Fig 8.4 that low density lipoprotein cholesterol (LDLC) was not significantly different among four age groups in obese categories. The results of ANOVA showed a significant ($p<0.05$) in difference low density lipoprotein cholesterol (LDLC) among four age groups in normal weight and overweight categories of boys.

On the other hand, significance ($p<0.05$) of LDLC were observed in every pairs age groups except among 5- <7 and 7 - < 9 years and 9 - <11 years and 11 – <13 in normal weight age groups and 7 - < 9 years, 9 - <11 years and 11 – <13 years age groups in overweight boys. It is noted from the Fig 8.5 that total cholesterol to high density lipoprotein cholesterol (TC: HDLC) was not significantly different among four age groups in normal weight and obese categories of boys. Total cholesterol to high density lipoprotein cholesterol (TC: HDLC) ratio differed significantly ($p<0.05$) between 5 - <7 years and 11 - <13 years age groups in overweight boys.

Fig. 8.1. Comparison total cholesterol (TC) among four age groups in each of three body weight catgory



Values are mean ± SD

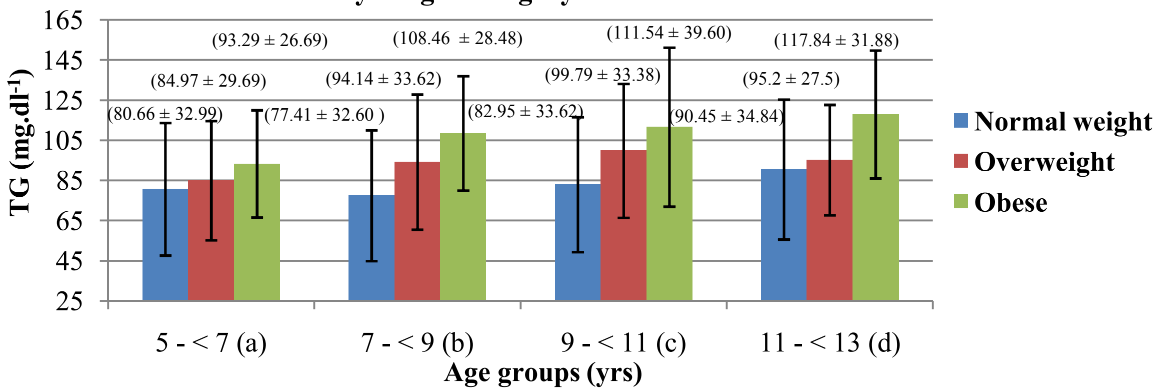
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of total cholesterol (TC) among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd'; ns = not significant

For Normal weight boys, F = 4.89 ($p<0.05$); ac, ad

For Overweight boys, F = 9.78 ($p<0.05$); ac, ad

For Obese boys, F = 1.52 ($p<0.05$); ns

Fig. 8.2. Comparison of triglycerides (TG) among four age groups in each three body weight category



Values are mean ± SD

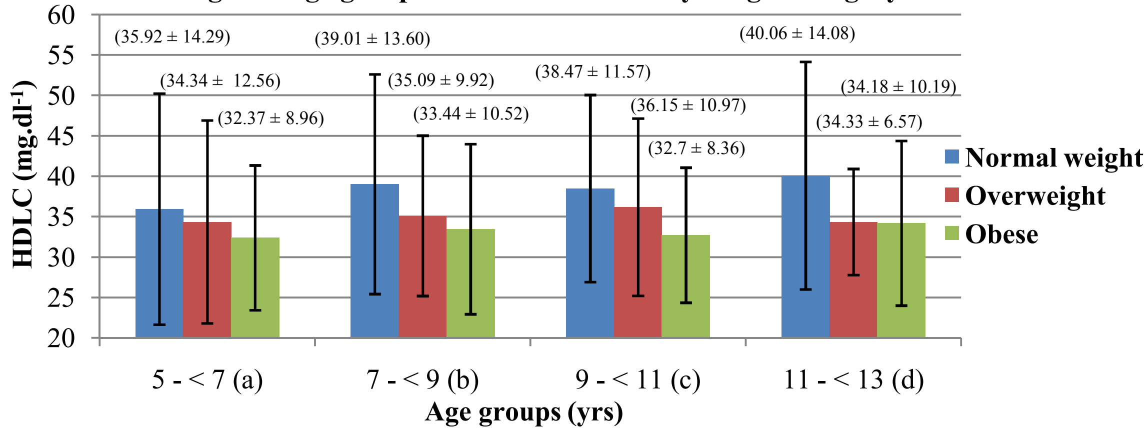
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of triglycerides (TG) among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ad) indicates 'a' significantly ($p < 0.05$) differed from'd'; ns = not significant

For Normal weight boys, F = 1.15 ($p<0.05$); ns

For Overweight boys, F = 1.40 ($p<0.05$); ns

For Obese boys, F = 3.50 ($p<0.05$); ad

Fig. 8.3. Comaprison of high density lipoprotein cholesterol (HDLC) among four age groups in each of three body weight category



Values are mean ± SD

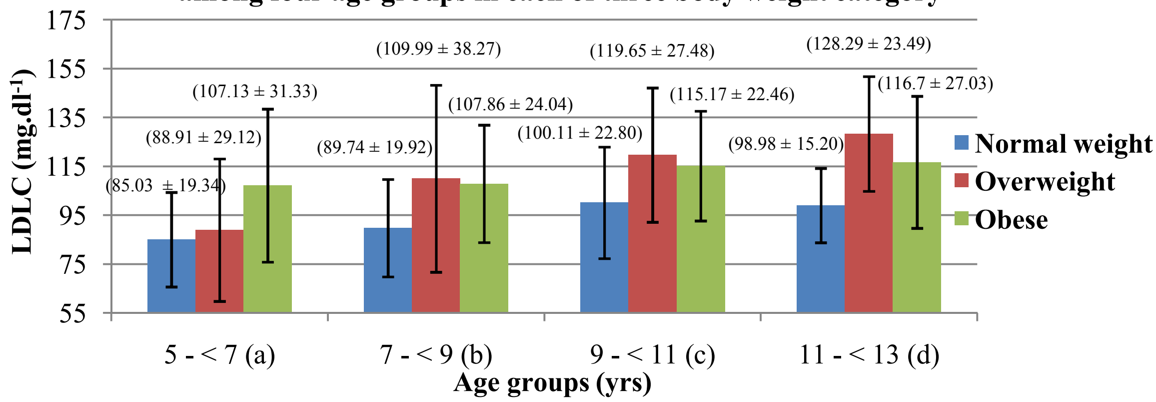
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of high density lipoprotein cholesterol (HDLC) among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; ns = not significant

For Normal weight boys, F = 0.69 ($p<0.05$); ns

For Overweight boys, F = 0.25 ($p<0.05$); ns

For Obese boys, F = 0.24 ($p<0.05$); ns

Fig. 8.4. Comparison of low density lipoprotein cholesterol (LDLC) among four age groups in each of three body weight category



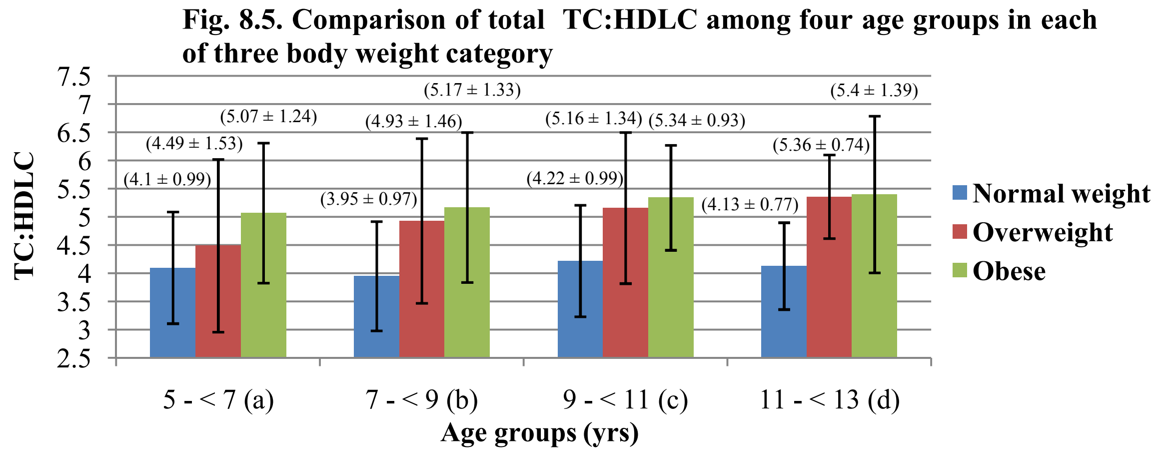
Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of low density lipoprotein cholesterol (LDLC) among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd'; ns = not significant

For Normal weight boys, F = 5.70 ($p<0.05$); ac, ad

For Overweight boys, F = 11.64 ($p<0.05$); ab, ac, ad

For Obese boys, F = 1.14 ($p<0.05$); ns



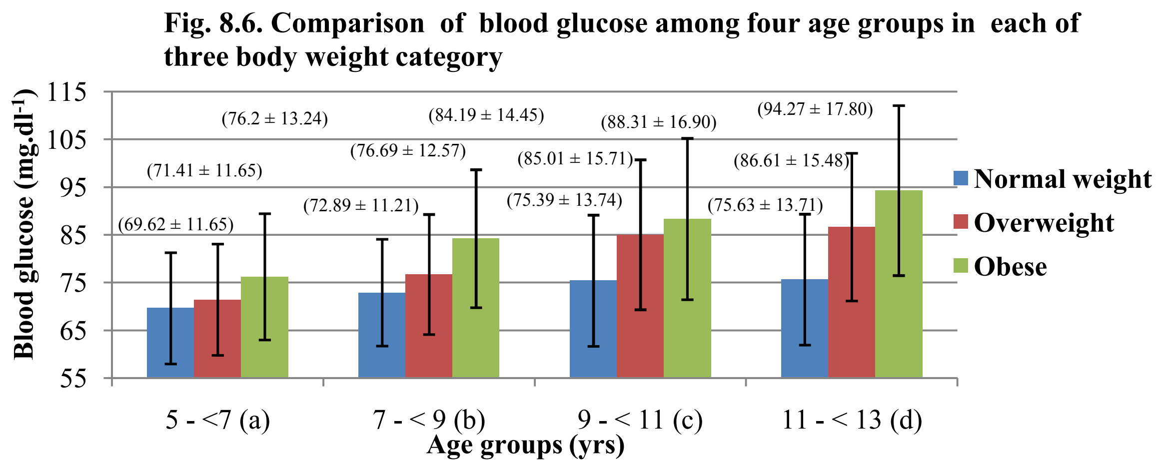
Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of TC: HDLC among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ad) indicates 'a' significantly ($p < 0.05$) differed from'd'; ns = not significant

For Normal weight boys, F = 0.64 ($p<0.05$); ns

For Overweight boys, F = 3.05 ($p<0.05$); ad

For Obese boys, F = 0.49 ($p<0.05$); ns



Values are mean ± SD

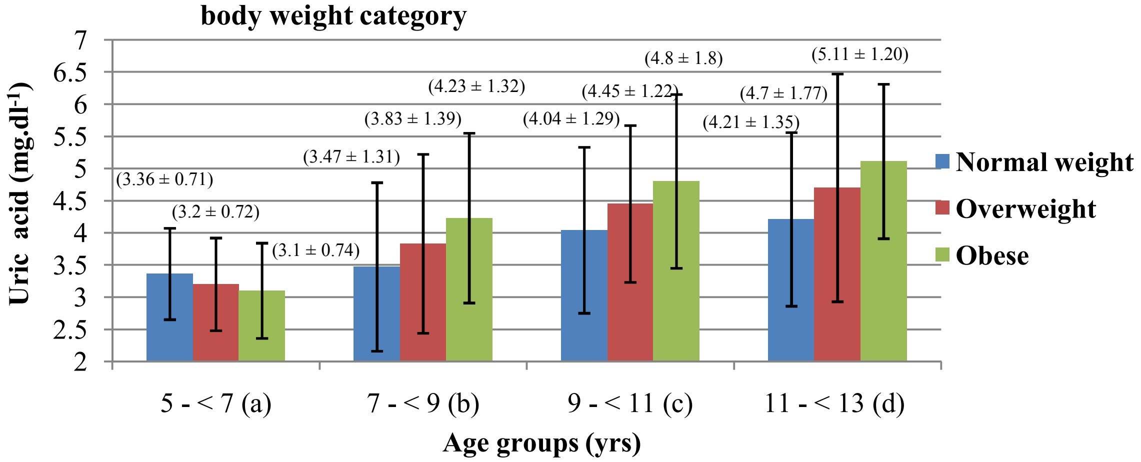
One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of blood glucose among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd'; ns = not significant

For Normal weight boys, F = ns ($p<0.05$); ns

For Overweight boys, F = 9.30 ($p<0.05$); ac, bc, bd

For Obese boys, F = 7.69 ($p<0.05$); ac, ad

Fig 8.7. Comparison of uric acid among four age groups in each of three body weight category



Values are mean ± SD

One way ANOVA (expressed by F values and level of significance) was conducted to show the overall difference of uric acid among four age groups in each of three body weight category, followed by Scheffe's multiple comparison test performed between the age groups a, b, c & d in each body weight category; (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (ad) indicates 'a' significantly ($p < 0.05$) differed from 'd', (bd) indicates 'b' significantly ($p < 0.05$) differed from 'd'; ns = not significant

For Normal weight boys, F = 4.93 ($p<0.05$); ac, bd

For Overweight boys, F = 8.84 ($p<0.05$); ac, ad

For Obese boys, F = 18.51 ($p<0.05$); ab, ac, ad, bd

It is evident from Fig 8.6 that blood glucose was not significantly different among four age groups in normal weight categories of boys. On the other hand, it is observed from the table that blood glucose differed significantly (p<0.05) among 5 - <7 years, 9 - <11 and 7 – <9 years, 11 - <13 in overweight categories and in 5 - <7 years, 9 - <11 and 5 - <7 years, 11 - <13 years age groups in obese categories of boys.

In Fig 8.7 comparison of uric acid among four age groups in each of three body weight categories has been presented. Fig 8.7 demonstrated that uric acid differed significantly (p<0.05) among four age groups in all three body weight categories. Overall we found an increasing trend of uric acid with age in all three body weight categories of boys.

8.3.9. Comparison of selective percentiles values of biochemical parameters among three body weight categories of boys in four different age groups

Comparison of 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles values of biochemical parameters among three body weight categories in four different age groups are presented in Table 8.8 to 8.14.

It is observed from the Table 8.8 that the 50th to 95th percentile values of total cholesterol (TC) were higher in overweight categories than in normal categories in all age groups. In, addition the lowest (5th) to highest (95th) percentile values of total cholesterol (TC) were higher in obese categories compared to normal weight categories in all age groups. It is also evident from the table that lowest (5th) to (25th) percentile values of total cholesterol (TC) were higher in overweight categories compared to obese categories in all age groups.

It is noted from the Table 8.9 that the 5th to 95th percentile values of triglycerides (TG) were higher in obese boys than in normal weight boys in all selected age groups. On the other hand, the lowest (5th) to highest (95th) percentiles values of triglycerides (TG) were also higher in obese categories compared to overweight categories. It is evident from the Table 8.10 that the 5th, 10th, 25th, 50th, 75th, 90th and 95th percentile values of high density lipoprotein cholesterol (HDLC) were higher in normal weight categories than overweight and obese categories. It is observed from Table 8.11 that the lowest (5th) to highest (95th) percentile values of total low density lipoprotein cholesterol (LDLC) were higher in obese boys compared to normal weight categories in all age groups. In contrast, lowest (5th) to highest (95th) of low density lipoprotein cholesterol (LDLC) were higher in overweight categories than in obese categories in 11 - <13 years age groups.

Table 8.8. Comparison of selective percentiles values of total cholesterol (TC) among three body weight categories of four different age groups

Age groups (years)	Ctgry.	F	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 106)	NW	40	137.09	27.45	101.80	108.85	119.13	130.24	153.63	178.45	192.86
	OW	34	140.25	34.38	103.02	107.60	113.02	132.5	143.84	205.27	218.79
	OB	32	158.16	36.64	106.80	110.50	122.50	169.32	182.97	195.55	223.00
7 - < 9 (N = 108)	NW	43	144.23	24.34	115.62	117.12	124.00	140.72	155.40	172.6	187.50
	OW	34	163.91	42.13	122.60	125.44	127.60	146.30	185.40	239.60	245.50
	OB	31	163.00	31.43	120.60	128.50	132.56	167.70	182.20	197.66	228.60
9 - < 11 (N = 110)	NW	40	155.18	28.88	125.47	127.82	131.34	145.05	185.19	194.32	210.53
	OW	37	175.77	33.80	136.65	139.45	145.60	167.64	197.00	225.25	240.45
	OB	33	170.19	34.13	131.45	134.92	140.11	159.77	196.47	222.34	236.40
11 - < 13 (N = 118)	NW	42	157.13	28.20	128.21	128.81	136.54	147.49	173.24	192.65	219.56
	OW	40	181.66	29.60	136.99	142.85	153.00	184.99	198.20	222.99	229.00
	OB	36	174.45	33.79	127.64	128.65	141.91	175.60	197.95	219.60	235.55

NW = normal weight; OW = overweight; OB = obese; Ctgry. = category; F = frequency

Table 8.9. Comparison of selective percentiles values of triglyceride (TG) among three body weight categories of four different age groups

Age groups (years)	Ctgry.	F	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 106)	NW	40	80.68	32.99	33.07	37.42	52.37	78.86	108.79	125.09	132.44
	OW	34	84.97	29.69	39.64	48.55	66.13	84.46	98.00	130.72	144.46
	OB	32	93.29	26.69	55.66	57.66	74.55	90.60	110.6	132.00	146.5
7 - < 9 (N = 108)	NW	43	77.41	32.60	38.87	40.76	49.21	73.99	107.56	119.38	122.20
	OW	34	94.14	33.62	54.40	55.40	70.50	86.40	122.40	145.40	152.20
	OB	31	108.46	28.48	58.55	76.55	87.50	104.00	132.20	140.60	150.00
9 - < 11 (N =110)	NW	40	82.95	33.62	29.13	34.47	58.52	85.02	102.27	129.57	137.29
	OW	37	99.79	33.38	48.67	56.44	73.67	94.56	125.60	142.44	160.40
	OB	33	111.54	39.60	56.78	64.55	76.54	100.16	146.66	165.50	170.76
11 - < 13 (N = 118)	NW	42	90.45	34.84	31.21	42.22	65.22	95.53	120.56	134.90	141.56
	OW	40	95.20	27.50	47.59	53.94	75.10	101.06	114.94	130.99	133.60
	OB	36	117.84	31.88	61.24	72.55	94.02	121.15	140.28	162.65	165.55

NW = normal weight; OW = overweight; OB = obese; Ctgry. = category; F = frequency

Table 8.12 demonstrated that lowest 5th to highest 95th percentiles values of total cholesterol to high-density lipoprotein cholesterol ratio (TC: HDLC) were higher in obese categories than that in normal weight categories in all age groups. On the other hand, lowest 5th to highest 95th percentile values of TC: HDLC were higher in overweight categories than that in normal weight categories in all age groups.

Table 8.10. Comparison of selective percentiles values of high density lipoprotein cholesterol (HDLC) among three body weight categories of four different age groups

Age groups (years)	Category	F	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 106)	NW	40	35.92	14.29	21.33	24.86	27.49	31.16	39.2	59	74.06
	OW	34	34.34	12.56	17.50	19.66	27.66	32.00	42.13	52.94	60.44
	OB	32	32.27	8.96	19.67	20.66	26.10	30.55	37.13	44.50	46.70
7 - < 9 (N = 108)	NW	43	39.01	13.60	25.94	26.60	29.80	34.50	43.24	64.40	68.50
	OW	34	35.09	9.92	21.33	24.32	26.66	34.63	39.60	50.70	54.40
	OB	31	33.44	10.52	20.60	23.45	25.50	30.44	42.30	45.66	54.60
9 - < 11 (N = 110)	NW	40	38.47	11.57	25.33	26.05	30.36	36.85	41.83	52.00	64.25
	OW	37	36.15	10.97	20.45	23.45	29.45	34.44	43.45	50.00	60.44
	OB	33	32.70	8.36	20.35	23.44	25.99	30.43	38.33	45.55	48.77
11 - < 13 (N = 118)	NW	42	40.06	14.08	26.78	27.85	29.49	36.47	43.33	68.50	74.45
	OW	40	34.33	6.57	24.78	25.91	29.21	33.05	40.50	42.90	46.19
	OB	36	34.18	10.19	19.69	23.90	26.57	31.09	39.80	50.50	54.60

NW = normal weight; OW = overweight; OB = obese; F = frequency

Table 8.11. Comparison of selective percentiles values of low density lipoprotein cholesterol (LDLC) among three body weight categories of four different age groups

Age group (years)	Ctgry.	F	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 106)	NW	40	85.03	19.34	55.32	58.62	71.86	82.63	99.63	112.68	119.88
	OW	34	88.91	29.12	56.26	58.73	68.75	85.30	102.64	133.54	156.29
	OB	32	107.13	31.33	61.37	62.53	81.34	111.97	129.40	139.84	161.16
7 - < 9 (N = 108)	NW	43	89.74	19.92	61.85	63.66	77.12	86.27	100.16	113.76	130.29
	OW	34	109.99	38.27	61.48	67.74	81.22	102.69	134.85	165.15	189.65
	OB	31	107.86	24.04	79.82	83.20	86.11	103.54	123.12	132.08	170.12
9 - < 11 (N = 110)	NW	40	100.11	22.80	70.36	78.82	84.35	93.10	110.49	132.09	147.78
	OW	37	119.65	27.48	76.75	86.13	99.47	116.02	138.29	159.68	172.86
	OB	33	115.17	22.46	87.98	91.13	95.79	110.66	132.16	150.45	154.91
11 - < 13 (N = 118)	NW	42	98.98	15.20	80.92	81.62	88.25	95.11	111.20	118.04	122.34
	OW	40	128.29	23.49	92.89	101.0	109.5	127.32	144.24	162.62	169.78
	OB	36	116.70	27.03	77.40	80.77	97.29	113.61	139.51	153.82	163.92

NW = normal weight; OW = overweight; OB = obese; Ctgry. = category; F = frequency

It is noted from the table 8.13 that the 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles values of blood glucose were higher in obese boys than normal weight categories and obese categories in all age groups. On the other hand, lowest 5th to highest 95th percentile of blood glucose were higher in overweight categories than normal weight categories in all age groups.

Table 8.12. Comparison of selective percentiles values of TC: HDLC among three body weight categories of four different age groups

Age groups (years)	Category	F	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 106)	NW	40	4.10	0.99	2.50	2.90	3.36	4.19	4.84	5.39	5.85
	OW	34	4.49	1.53	2.28	2.65	3.21	4.46	5.22	6.76	7.51
	OB	32	5.07	1.24	3.08	3.40	4.17	5.02	5.79	6.55	6.65
7 - < 9 (N = 108)	NW	43	3.95	0.97	2.47	2.61	3.10	3.87	4.61	5.13	5.53
	OW	34	4.93	1.46	2.52	3.04	3.58	5.22	6.12	6.70	7.45
	OB	31	5.17	1.33	3.47	3.65	4.00	5.05	6.56	6.82	7.38
9 - < 11 (N = 110)	NW	40	4.42	0.99	2.89	3.11	3.50	4.07	4.81	5.40	6.26
	OW	37	5.16	1.34	3.12	3.27	4.27	4.80	6.20	6.89	6.98
	OB	33	5.34	0.93	3.87	4.16	4.61	5.25	6.17	6.67	6.75
11 - < 13 (N = 118)	NW	42	4.13	0.77	2.94	3.08	3.66	4.23	4.72	4.93	5.19
	OW	40	5.36	0.74	4.09	4.48	4.79	5.41	5.87	6.29	6.47
	OB	36	5.40	1.39	3.38	3.53	4.22	5.27	6.67	7.43	7.54

NW = normal weight; OW = overweight; OB = obese; F = frequency

Table 8.13. Comparison of selective percentiles values of blood glucose among three body weight categories of four different age groups

Age groups (years)	Category	F	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 106)	NW	40	69.62	11.65	52.02	55.81	59.18	70.06	77.63	82.72	91.36
	OW	34	71.42	11.65	56.66	60.24	64.5	68.6	75.49	88.84	99.49
	OB	32	76.20	13.24	62.4	63.6	64.65	72.7	85.55	96.6	105.6
7 - < 9 (N = 108)	NW	43	72.89	11.21	58.03	59.24	64.6	74.68	78.8	86.07	91.64
	OW	34	76.69	12.57	62.35	63.38	69.66	73.12	84.6	97.4	104.45
	OB	31	84.19	14.45	65.55	67.5	70.78	82.34	96.54	104.5	106.55
9 - < 11 (N = 110)	NW	40	75.39	13.74	58.04	58.89	64.56	72.65	84.45	96.61	101.47
	OW	37	85.01	15.71	66.45	67.5	72.5	80.4	97.6	110.5	115.4
	OB	33	88.31	16.90	68.78	70.15	73.64	82.45	104.5	115.5	116.87
11 - < 13 (N = 118)	NW	42	75.63	13.71	58.33	60.54	64.55	73.79	82.3	96.6	102.4
	OW	40	86.61	15.48	70.47	70.69	74.90	81.63	100.32	112.1	117
	OB	36	94.33	17.54	76.34	75.54	79.99	88.39	111.52	122.5	125.53

NW = normal weight; OW = overweight; OB = obese; F = frequency

It is evident from the table 8.14 that the all seven percentiles values of blood uric acid were higher in obese boys than normal weight categories in all age groups except 5 - <7 years age groups, where highest 95th percentile values uric acid was higher in normal weight boys compared to obese boys.

Table 8.14. Comparison of selective percentiles values of uric acid among three body weight categories of four different age groups

Age groups (years)	Category	F	Mean	SD	Percentile						
					5th	10th	25th	50th	75th	90th	95th
5 - < 7 (N = 106)	40	40	3.36	0.71	2.22	2.52	2.87	3.29	3.72	4.50	4.70
	34	34	3.20	0.72	2.23	2.24	2.53	3.30	3.87	4.25	4.45
	32	32	3.10	0.74	2.21	2.30	2.40	3.02	3.63	4.21	4.53
7 - < 9 (N = 108)	43	43	3.47	1.31	2.20	2.28	2.57	3.03	3.86	5.97	6.25
	34	34	3.83	1.39	2.40	2.44	2.77	3.45	4.50	6.40	7.20
	31	31	4.23	1.32	2.89	2.95	3.22	3.84	5.25	6.44	6.67
9 - < 11 (N = 110)	40	40	4.04	1.29	2.81	2.93	3.35	3.57	4.19	6.63	7.30
	37	37	4.45	1.22	2.98	3.10	3.45	4.21	5.30	6.40	7.40
	33	33	4.80	1.35	3.42	3.45	3.74	4.37	5.51	6.98	7.60
11 - < 13 (N = 118)	42	42	4.21	1.35	2.72	2.78	3.11	4.00	5.23	6.40	6.70
	40	40	4.70	1.77	2.86	2.90	3.17	3.79	5.94	7.60	8.30
	36	36	5.11	1.20	3.90	3.95	4.20	4.78	5.72	7.30	7.90

NW = normal weight; OW = overweight; OB = obese; F = frequency

8.3.10. Correlations coefficient of age with selected biochemical parameters

It is revealed from the Table 8.15 total cholesterol, triglycerides, high density lipoprotein cholesterol, low density lipoprotein cholesterol, ratio of total cholesterol to high density cholesterol, blood glucose and uric acid were positively correlated with the age. All the above correlations were found to be significant except high density lipoprotein cholesterol, where no significant correlation existed with age.

8.3.11. Correlations coefficient of BMI and body fat% with selected biochemical parameters

Table 8.16 represents the relation of BMI and body fat% with selected biochemical parameters. It is evident from the table that all the biochemical variables were significantly and positively correlated with the BMI and body fat% except HDLC, where BMI and body fat% were significantly and negatively correlated with the HDLC.

8.3.12. Correlations coefficient of WHR and WTR with selected biochemical parameters

It is observed from the Table 8.17 that relation of WHR and WTR with selected biochemical parameters were positively correlated. It is noted from the table that all the biochemical parameters were significantly and positively correlated with the WHR and WTR except HDLC, where WHR and WTR were significantly and negatively correlated with the HDLC.

Table 8.15. Pearson's Product moment correlation coefficient of age with selected biochemical parameters

Variables	Age (years) (N = 442)		
	r	95% CI	Level of significance
TC ($mg.dl^{-1}$)	0.289	0.201 to 0.372	p< 0.001
TG ($mg.dl^{-1}$)	0.162	0.070 to 0.251	0.006
HDLC ($mg.dl^{-1}$)	0.054	-0.039 to 0.146	ns
LDLC ($mg.dl^{-1}$)	0.292	0.202 to .375	p< 0.001
TC:HDLC	0.135	0.042 to 0.226	0.0043
Blood glucose ($mg.dl^{-1}$)	0.311	0.224 to 0.393	p< 0.001
Uric acid ($mg.dl^{-1}$)	0.392	0.310 to 0.468	p< 0.001
ns = not significant, 95 % CI = 95% confidence intervals			

Table 8.16. Pearson's Product moment correlation coefficient of BMI and % of Fat with selected biochemical parameters

Variables	BMI(kg/m^2) (N = 442)			Body fat% (N = 442)		
	r	95% CI	Level of significance	r	95% CI	Level of significance
TC ($mg.dl^{-1}$)	0.298	0.211 to 0.381	p< 0.001	0.271	0.182 to 0.355	p< 0.001
TG ($mg.dl^{-1}$)	0.327	0.241 to 0.408	p< 0.001	0.299	0.212 to 0.382	p< 0.001
HDLC ($mg.dl^{-1}$)	-0.161	-251 to - 0.069	0.006	- 0.169	- 0.258 to 0.007	0.004
LDLC ($mg.dl^{-1}$)	0.354	0.269 to 0.432	p< 0.001	0.330	0.244 to 0.411	p< 0.001
TC:HDLC	0.391	0.309 to 0.467	p< 0.001	0.375	0.292 to 0.453	p< 0.001
Blood glucose ($mg.dl^{-1}$)	0.429	0.350 to 0.503	p< 0.001	0.362	0.279 to 0.441	p< 0.001
Uric acid ($mg.dl^{-1}$)	0.320	0.234 to 0.401	p< 0.001	0.290	0.202 to 0.373	p< 0.001
ns = not significant; 95 % CI = 95% confidence intervals						

8.3.13. Pearson's Product moment correlations coefficient of SBP and DBP with selected biochemical parameters

Table 8.18 represents the relation of SBP and DBP with selected biochemical parameters. It is evident from the table that SBP and DBP were negatively correlated with HDLC. On the other hand, SBP and DBP were significantly and positively correlated with others biochemical variables.

Table 8.17. Pearson's Product moment correlation coefficient of WHR and WTR with selected biochemical parameters

Variables	WHR (N = 442)			WTR (N = 442)		
	r	95% CI	Level of significance	r	95% CI	Level of significance
TC ($mg.dl^{-1}$)	0.178	0.084 to 0.259	p<0.01	0.006	-0.086 to 0.012	ns
TG ($mg.dl^{-1}$)	0.182	0.091 to 0.271	p<0.01	0.044	-0.523 to 0.134	ns
HDLC ($mg.dl^{-1}$)	- 0.230	-0.316 to -0.139	p< 0.001	- 0.12	-0.211 to 118	0.0113
LDLC ($mg.dl^{-1}$)	0.194	0.103 to 0.283	p< 0.01	0.031	-0.062 to 0.124	ns
TC:HDLC	0.342	0.257 to 0.422	p< 0.001	0.132	0.400 to 0.223	0.0051
Blood glucose ($mg.dl^{-1}$)	0.228	0.137 to 0.314	p< 0.001	0.079	-0.013 to 0.171	ns
Uric acid ($mg.dl^{-1}$)	0.019	-0.074 to 0.112	ns	0.098	-0.083, 0.141	0.038
ns = not significant, 95 % CI = 95% confidence intervals						

Table 8.18. Pearson's Product moment correlation coefficient of SBP and DBP with different biochemical parameters

Variables	SBP(mmHg) (N = 442)			DBP(mmHg) (N = 442)		
	r	95% CI	Level of significance	r	95% CI	Level of significance
TC ($mg.dl^{-1}$)	0.16	0.072 to 0.254	0.005	0.12	0.034 to 0.217	0.0074
TG ($mg.dl^{-1}$)	0.12	0.332 to 0.216	0.0079	0.10	0.013 to 0.197	0.0251
HDLC ($mg.dl^{-1}$)	-0.09	-0.118 to -0.003	0.0244	-0.08	-0.175 to 0.01	0.0810
LDLC ($mg.dl^{-1}$)	0.20	0.118 to 0.297	< 0.001	0.16	0.07 to 0.252	0.0006
TC:HDLC ($mg.dl^{-1}$)	0.18	0.094 to 0.275	< 0.01	0.15	0.059 to 0.241	0.0014
Blood glucose ($mg.dl^{-1}$)	0.22	0.138 to 0.315	< 0.001	0.19	0.105 to 0.285	p< 0.01
Uric acid ($mg.dl^{-1}$)	0.01	0.075 to 0.001	ns	0.002	-0.090 to 0.095	ns
ns = not significant, 95 % CI = 95% confidence intervals						

Table 8.19. Multiple regression analysis of total cholesterol (TC), triglyceride (TG), HDLC, LDLC, TC: HDLC, blood sugar and uric acid on age, BMI, body fat %

TC is dependent variable									
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
Age	88.72	3.15	0.75	0.20	4.15	p<0.001	20.73	p<0.001	0.11
BMI		2.07	1.44	0.19	1.44	0.15			
Body fat%		0.17	0.76	0.02	0.22	0.822			
TG is dependent variable									
Age	22.86	0.57	0.75	0.03	0.76	0.44	17.77	p<0.001	0.10
BMI		3.69	1.44	0.34	2.56	p<0.01			
Body fat%		0.19	0.76	0.33	0.25	0.88			
HDLC is dependent variable									
BMI	43.10	0.20	0.50	0.05	0.40	0.685	12.84	p<0.001	0.05
Body fat%		- 0.60	0.28	- 0.28	- 2.16	0.031			
LDLC is dependent variable									
Age	46.36	2.27	0.61	0.18	3.73	p<0.001	25.55	p<0.001	0.15
BMI		1.18	0.62	0.13	1.88	0.060			
Body fat%		0.82	0.33	0.16	2.50	0.013			
TC: HDLC is dependent variable									
Age	41.94	2.34	0.60	0.18	3.85	p<0.001	26.61	p<0.001	0.15
BMI		1.84	1.15	0.20	1.59	0.112			
Body fat%		0.38	0.61	0.07	0.61	0.538			
Blood glucose is dependent variable									
Age	24.31	1.10	0.33	0.15	3.31	p<0.001	26.60	p<0.001	0.14
BMI		3.09	0.63	0.61	4.90	p<0.001			
Body fat%		0.68	0.33	0.24	0.20	0.04			
Uric acid is dependent variable									
Age	26.26	1.07	0.32	0.32	3.25	p<0.01	40.25	p<0.001	0.21
BMI		2.98	0.62	0.62	4.77	p<0.001			
Body fat%		0.67	0.33	033	0.20	0.044			

Table 8.20. Multiple regression analysis of total cholesterol (TC), triglyceride (TG), HDLC, LDLC, TC: HDLC and blood sugar on age, BMI, WHR

Independent Variables	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
TC is dependent variable									
Age	- 62.33	4.27	1.01	0.27	4.21	p<0.001	27.00	p<0.001	0.15
BMI		0.64	0.89	0.05	0.71	0.474			
WHR		182.4	49.94	0.28	3.66	p<0.001			
TG is dependent variable									
Age	- 99.20	0.78	1.07	0.04	0.72	0.46	22.04	p<0.001	0.13
BMI		1.64	0.94	0.14	1.73	0.08			
WHR		168.48	52.94	0.25	3.18	p<0.002			
HDLC is dependent variable									
BMI	59.93	- 0.06	0.17	- 0.01	- 0.36	0.719	76.63	p<0.001	0.60
WHR		- 0.48	0.43	-0.50	- 11.24	p<0.001			
LDLC is dependent variable									
Age	- 189	3.19	0.82	0.23	3.87	p<0.001	55.01	p<0.001	0.27
BMI		0.33	0.72	.035	0.46	0.642			
WHR		278.09	40.48	0.49	6.86	p<0.001			
TC: HDLC is dependent variable									
Age	- 3.23	0.07	0.03	0.13	2.10	0.036	31.37	p<0.001	0.17
BMI		0.06	0.03	0.16	2.07	0.039			
WHR		6.34	6.34	0.27	3.52	p<0.001			
Blood glucose is dependent variable									
Age	2.24	1.75	0.45	0.24	3.88	p<0.001	42.11	p<0.001	0.22
BMI		1.33	0.39	0.26	3.35	p<0.01			
WHR		38.26	22.19	0.12	1.72	0.085			

8.3.14. Multiple linear regression analysis

Multiple linear regression analysis was performed to see the independent relationship of different anthropometric obesity markers with selected biochemical markers those are representative of coronary artery disease and standard partial regression coefficients (β) have been presented for this purpose (Table 8.19 and 8.20). The models were controlled several factors.

In multiple regressions analysis demonstrated (Table 8.19) that all the biochemical variables were positively associated with the BMI and body fat% except HDLC, where BMI and body fat% were negatively associated with the HDLC. It is also obtained from the Table 8.19 that the BMI was significantly and positively related with TG, blood glucose and uric acid, when age and body fat% were controlled. Table 8.19 also demonstrated that age had strong independent significant ($p<0.001$) and positive relation with the blood glucose and uric acid.

On the other hand, Table 8.20 represented that waist to hip ratio (WHR) had strong independent significant ($p<0.001$) and positive association with all the biochemical variables except for high density lipoprotein cholesterol (HDLC), where the relationship was found to be the reverse. So, waist to hip ratio (WHR) is partly good predictor for variability of the selected biochemical parameters.

8.4. Discussion

The present study was based on comparative analysis of selected anthropometric, physiological and biochemical parameters related to the risk of coronary artery disease in 5 to 12 years old school going Bengali boys in West Bengal. There were marked differences in biochemical, anthropometric and physiological variables among three body weight categories.

It is evident from Table 8.1 to 8.4 that the range of total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDLC), blood glucose and uric acid in overweight and obese boys were found to be greater than the upper limit of recommended paediatric range **(Soldin et al., 1999**). Serum uric acid is the primary end product of purine metabolism in humans, and its levels are strictly controlled by the balance between production and excretion **(Chen et al., 2007).** A study of **Roberts et al., (2002)** demonstrated that uric acid clearance in the obese group was lower than in the control group, suggesting that hyperuricemia in the obese population would be mainly attributed to a decrease in the clearance of uric acid, rather than to an overproduction of urates.

On the other hand, the prevalence of hypertriglyceridemia in obese children with metabolic syndrome is very high in adolescents **(Cruz et al., 2004; de Ferranti et al., 2004; Grundy, 2007; Wassink, 2011).** The triglyceride reference interval remains higher during the first year of life, presumably due to milk-rich feeding. Following the first year, the values decrease to their lowest levels and then gradually increase with age in agreement with other studies which indicated a similar trend in regard to age (**Kottke et al., 1991; Jargoned et al., 1998).** Triglyceride levels increase gradually throughout childhood and adolescence (**Jargoned et al., 1998**).

It is revealed from the present study that mean values of total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDLC), and total cholesterol to high density lipoprotein cholesterol ratio (TC: HDLC) , blood glucose and uric acid were significantly greater in obese and overweight boys compared to normal weight categories (Table 8.5). The mean blood glucose level was notably higher in obese boys under 11 - <13 years of age and sometime exceeded the normal reference range of fasting blood glucose (i.e., 60-110 mg.dl^{-1}), **(Soldin et al., 1999)**. Many studies have explored the clinical significance of high fasting plasma glucose in obese children (**Maffeis et al., 2010; Grandone et al., 2008; O'Malley et al., 2010).** In a sample of 323 obese children, **Grandone et al., (2008)** showed that high normal fasting blood glucose (87 to 99 mg/dL) is associated with a sevenfold higher risk of occurrence of impaired glucose tolerance and insulin resistance. A significant and positive association between fasting blood glucose and resting blood pressure has been demonstrated previously in children with impaired fasting blood glucose **(Williams et al., 2005).** Our study provides the additional evidence that this relation was also positive between fasting blood glucose and resting blood pressure (Table 8.18). Thus the finding of high-normal serum plasma glucose in a clinical setting could contribute to an early detection of elevated blood pressure levels, a condition that is frequently underestimated in childhood **(Hansen et al., 2007).**

Present study also reveals that body mass index and body fat% were significantly higher in overweight and obese boys compared to normal weight boys in all age groups (Table 8.6). The mean values of BMI and body fat% were also higher in obese categories compared to overweight categories. On the other hand, the mean values of waist to hip ratio (WHR) and waist to thigh ratio (WTR) were significantly higher in obese and overweight boys than in normal weight boys. It is evident from the present study (Table 8.7) that the resting pulse rate, resting respiratory rate and resting blood pressure were significantly lower in normal weight categories than in overweight and obese boys.

The comparative analysis of serum lipids, blood glucose and uric acid among each four age groups revealed an increasing trend of total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDLC), total cholesterol to high density lipoprotein cholesterol ratio (TC: HDLC), blood glucose and uric acids with age in all three body weight categories of boys (Fig 8.1, 8.2. 8.4, 8.5, 8.6 and 8.7). Present findings corroborates well with the finding of **Hicks et al. (1996), Lockitch et al. (1988), Wennlof et al. (2005),** they reported that serum total cholesterol, triglycerides and blood glucose rise in early childhood than gradually decreased up to adolescence, although some investigators found no such increase **(Lauer et al., 1975; Srivasana et al., 1975)**. In contrast, sexual maturation is reported to decrease the levels of various serum lipids (**Wennlof et al., 2005; Godfrey et al., 1972; Friedmann et al., 1973; Rafii et al., 1994).**

It is evident from Table 8.10 to 8.14 that highest 95th percentile values of all selected serum lipid factors (TC, TG, LDLC, TC: HDLC), blood glucose and uric acid were higher in overweight and obese categories. Several studies have shown that the association between obesity and cardiovascular risk begins early in life (**Short et al., 2009; Bridger, 2009).** Body mass index (BMI) and waist circumference (WC) each measure a distinct component of obesity or body fat distribution, and central obesity marker waist to hip ratio (WHR) is consistently the best predictor of coronary artery disease (CAD) risk **(Hirschler et al., 2011; Bitsori et al., 2009).** Few studies are available on the relationship between waist to hip ratio (WHR) and cardiovascular risk factors in children with obesity **(Short et al., 2009; Bridger, 2009).** It is a evident (Table 8.16 and 8.17) from present study that there were positive correlations between anthropometric obesity markers (BMI, body fat %, WHR and WTR) with important coronary artery disease risk factors (TC, TG, LDLC, and TC: HDLC, blood glucose and uric acid**).**

In contrast, a significant and negative correlation was obtained between anthropometric obesity markers with good cholesterol (HDLC). It is also observed from the present study that resting blood pressure was positively correlated with serum lipid profile except HDLC, where negative correlation was observed between HDLC with blood pressure (Table 8.18). It is evident (Table 8.15) from present study there were positive correlations between age with blood lipid profiles (TC, TG, TC: HDLC), blood glucose and uric acids.

Moreover, multiple regressions analysis demonstrated (Table 8.19 and 8.20) that all the biochemical variables were positively associated with the selected anthropometric obesity markers except with good cholesterol (HDLC), where negative association was observed between HDLC with obesity parameters.

The results of the study (Table 8.20) showed significant and positive correlations between central obesity marker waist to hip ratio (WHR) and total cholesterol (TC), triglycerides (TG), and LDLC, and inverse correlation with HDLC. Moreover, multiple regressions analysis demonstrated (Table 8.20) that central obesity marker waist to hip ratio (WHR) was significantly and positively associated with the important coronary artery disease risk factors except good cholesterol (HDLC), where significant and negative association was observed between waists to hip ratio (WHR) with good cholesterol after adjustment for age and body mass index (BMI).

Present findings corroborates well with the finding of corroborated well with earlier studies **Falaschetti et al.(2010); Savva et al. (2000); Hirschler et al. (2005),** they demonstrating a significant association between WHR and blood lipid profile. **Hirschler et al.** in **2011** demonstrated a significant ($P<0.01$) association between waist to hip ratio (WHR) and total cholesterol (TC), high density lipoprotein cholesterol (HDLC), triglyceride (TG) levels in 84 students aged 6 to 13 years. On the other hand, **Cowin and Emmett** in **2000** reported that central obesity had a significant correlation with triglycerides and HDLC levels in preschool children that was independent of height and body mass index (BMI). The findings of the current study also agree with the results of the Bogalusa Heart Study, which reported an inverse association between central obesity marker and high density lipoprotein cholesterol (HDLC) in children aged 5 to 9 years **(Freedman et al., 2007).**

A blood lipid levels, especially decreased high density lipoprotein cholesterol (HDLC) and elevated total cholesterol (TC), triglycerides (TG), and low density lipoprotein cholesterol (LDLC), are generally recognized as independent risk factors for cardiovascular disease **(Pascot et al., 2002; Manios et al., 2004; Garcia et al., 1999) .**

Our study demonstrated an abnormal blood lipid profile with regard to elevated total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDLC), and reduced high density lipoprotein cholesterol (HDLC) in overweight or obese boys. Our results also show that overweight and obesity in children increases the likelihood of adverse coronary artery disease (CAD) risk factors, including increased waist hip ratio (WHR), high BMI, body fat percent and elevated fasting blood glucose, uric acid and hypercholesterolemia, hypertriglyceridemia, and low HDLC, which is consistent with previous studies **(Botton et al., 2007; Glowinska et al., 2002; Paoli et al., 2009; Carlsson et al., 2011; Oyama etal., 2006).**

Botton et al in **2007** showed partial correlations between hypertriglyceridemia, hyperinsulinemia, and low plasma HDL cholesterol levels that were related to all measures of adiposity in 452 children aged 8 to7 years. In addition, they demonstrated that excess body weight is linked with increased coronary artery disease risk, and among girls, abdominal fat distribution is correlated with cardiovascular risk factors independently of anthropometric obesity markers **(Botton et al., 2007).** In accordance with our findings, another study performed in Venezuela in a sample of 370 second grade students found a significant positive correlation between central obesity marker (WHR) , body mass index (BMI), and important coronary artery disease risk factors i.e., triglycerides, HDLC and LDLC **(Paoli et al., 2009).**

Moreover, **Lemos-Santos and Sichieri (2004)** also indicated that waist to hip circumference ratio (WHR) was positively correlated with serum cholesterol, triglyceride and LDLC in adult obese male subject. Dyslipidemia is more common in obese patients than in normal weight individuals (**Freedman et al., 1999; Yang et al., 2007-2009)**. In obesity, high amounts of free fatty acid are released due to lipolysis. These free fatty acids lead to triglyceridemia by inhibiting lipoprotein lipase in adipose and muscle tissues **(Haas et al., 2004; Gong et al**., **2014; Evia-Viscarra et al., 2013; Weisell, 2002; Gröber-Grätz et al., 2013)**.

Degradation of triglycerides rich low density lipoprotein cholesterol (LDLC) and high density lipoprotein cholesterol (HDLC) caused by triglyceridemia with hepatic lipase leads to increasing low LDLC levels and decreasing HDLC levels. Increased low density lipoprotein cholesterol and decreased high density lipoprotein cholesterol levels are major factors for development of coronary artery disease **(Klop et al., 2013; Holland et al; 2011; Holland et al., 2007; Savage et al., 2007; Erem et al., 1999; Pucci et al. 2000).** On the other hand, uric acid was positively associated with obesity indices (i.e., BMI and WHR) and WHR had strong positive association coronary artery disease risk factor **(Meshkani et al., 2011; Dehghan et al, 2008; Choi et al., 2008; Rosolowsky et al., 2008; Tanighuchi et al., 1998; Tuomilehto et al., 1988; Herman et al., 1976).**

In other studies **(Li et al., 2011; Lee et al., 2012; Liu et al., 2010; Barbosa et al., 2011 Choi et al., 2007),** those in the highest percentile of uric acid levels, the risks were substantially higher for metabolic syndrome compared with those in lowest percentile of uric acid levels. This suggests that higher uric acid levels are associated with metabolic syndrome **(Lim et al., 2010; Lin et al., 2006; Uaratanawong et al., 2011).** Moreover, **Facchini et al.,** (**1991)** had suggested that insulin impairment is the pathophysiological mechanism for the association.

So, it may be established from the present finding that boys who are overweight and obese at an increased risk of coronary artery disease due to higher level of BMI, body fat% and waist to hip ratio with unexpected lipid profile and elevated fasting blood glucose and uric acid. **Williams et al., (1992) and Caprio et al., (1996)** reported that overweight or obese children having increased risk of coronary artery diseases due to higher level of body fat% with abnormal lipid profile.

8.5. Conclusion

Obesity increases the prevalence and incidence of coronary artery diseases in children. BMI and central obesity marker (WHR) is the most powerful marker related to the metabolic abnormalities and coronary artery disease risk factors of obese and overweight boys. Serum total cholesterols (TC), triglycerides, LDLC and blood glucose levels were significantly higher in overweight and obese boys compared to the normal weight categories. On the other hand, all the selected anthropometric obesity and physiological parameters were significantly higher in overweight and obese boys than in normal weight boys. Waist to hip circumference ratio (WHR) was significantly and positively correlated with serum cholesterol, triglyceride, LDLC, blood glucose and significantly and negatively correlated with the HDLC. Our study demonstrated that among the anthropometric obesity indices, just waist to hip circumference had a correlate on significantly with all the selected coronary artery disease risk factors. From our study revealed that waist to hip ratio (WHR) is independently good predictor of abnormalities in lipid profile in 5 to 12 years old school going Bengali boys. This finding has significant children health implications of West Bengal in India, given the associations between obesity, waist hip ratio, BMI and body fat %, metabolic abnormalities of the lipid profile, and cardiovascular risk in adult life. This suggests that control of excessive body weight gain in children is likely to have long term benefits.

Nutrition in Childhood obesity

Chapter IX

9.1. Introduction

The widely used clinical term 'obesity' derives from the Latin *ob* standing for 'on account of', and *esum,* meaning 'having eaten'. Unhealthy lifestyle and eating habits have been associated with increasing prevalence of diet related non-communicable diseases such as obesity, diabetes, cardiovascular and hypertension in developing countries like India. Overweight and obesity are influenced by many factors including hereditary tendencies, environmental factors and behavioural factor **(Trowbridge et al., 2002).** It is difficult to determine among these which one has the most powerful factor effect on obesity. However, some evidence suggested that dietary factors and physical activity patterns are strongly associated with increasing weight gain **(Miller et al., 1994; Olivares et al., 2004; Liebman et al., 2003; Moreno et al., 2000).** The increased prevalence of overweight and obesity in Indian children may be attributed to decreasing physical activity and increasing food energy intake **(Vijayapushpam et al., 2003)**. Some studies have suggested that the increased incidence of overweight and obesity could be the result of an increase in the consumption of foods that are high in fat **(Danforth, 1985; Prentice, 1994)**. There is no published data on the relationship between overweight or obesity, and dietary intake in Indian children. The objectives of the present study to compare the nutritional status among normal weight, overweight and obese boys in terms of nutrient intake and also its relation to the obesity, motor quality parameters and certain risk factors development of coronary artery disease.

9.2. Materials and Methods

The present study was carried-out in 1036 healthy school going Bengali boys aged between 5 to 12 years. Dietary information had been obtained by 24-hour dietary recalls method conducted on participants. The participants were grouped according to age, 5 - < 7, 7 - < 9, 9 - < 11 and 11 - < 13.

On the basis of BMI-age-boys Z-scores (normal weight: - 2SD > BMI Z score ≤ + 1SD, overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD), boys were categorised in three sub-divisions such Normal weight, Overweight and Obese **(WHO, 2007)**.

All the selected anthropometric (i.e., BMI and body fat %), physiological (i.e., resting SBP and DBP) and nutritional variables were determined by standard procedures which have been elaborately discussed in Chapter III.

9.3. Results

9.3.1. Comparison of intake of different macronutrients among three body weight categories in four different age groups of boys

Comparisons of selected macronutrient intakes among three body categories in each of the four age groups of boys are presented in Table 9.1

One way ANOA was performed to make an overall comparison of the selected macronutrient intakes among three body weight categories in each of the four age groups. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for a particular age group.

It is observed from the table 9.1 that intake of carbohydrate, fat and calorie differed significantly ($p<0.05$) among three body weight categories in all age groups. Moreover post hoc analysis revealed that all pair of body weight categories in the above mentioned macronutrient intake showed significant ($p<0.05$) difference. On the other hand, the mean values of carbohydrate, calorie and fat were remarkably higher in obese categories compared to overweight and normal weight categories.

Table 9.1. Comparison of dietary intakes of different macronutrients among three body weight categories of boys from four different age groups

Age group (years)	Category	Carbohydrate (gm/day)	Protein (gm/day)	Fat (gm/day)	Calorie (Kcal/day)
5 – < 7 (N = 245)	NW (a) (n = 142)	241.99 ± 53.94	27.85 ± 6.59	21.67 ± 5.05	1274.45 ± 230.75
	OW (b) (n = 61)	277. 50 ± 45.13	24.84 ± 6.87	28.18 ± 6.09	1463.07 ± 185.32
	OB (c) (n = 42)	302.95 ± 37.67	24.86 ± 7.72	31.32 ± 6.52	1593.20 ± 145.78
F value		29.05	5.74	61.83	45.29
Level of significance		*(ab)((ac)	*(ab)((ac)	*(ab)(ac)(bc)	*(ab)(ac)(bc)
RDA		-	20.1	25.00	1350
7 - < 9 (N = 261)	NW (a) (n = 146)	303.26 ± 67.01	36.97 ± 13.58	26.46 ± 7.14	1601.90 ± 273.9
	OW (b) (n = 72)	342.35 ± 49.16	34.46 ± 11.54	33.59 ± 6.50	1809.63 ± 213.04
	OB (c) (n = 43)	349.48 ± 63.46	31.48 ± 12.96	42.60 ± 11.38	1907.33 ± 290.05
F value		14.76	3.23	75.44	30.06
Level of significance		*(ab)(ac)	ns	*(ab)(ac)(bc)	*(ab)(ac)(bc)
RDA		-	29.5	30	1690
9 - < 11 (N = 263)	NW (a) (n = 146)	357.38 ± 53.05	44.10 ± 13.19	33.05 ± 7.26	1903.44 ± 220.50
	OW (b) (n = 63)	379.49 ± 46.24	45.83 ± 15.10	41.47 ± 11.04	2074.62 ± 206.62
	OB (c) (n = 53)	388.83 ± 44.42	41.59 ± 13.58	51.47 ± 14.66	2184.50 ± 213.29
F value		9.58	1.38	66.90	37.83
Level of significance		* (ac)	ns	*(ab)(ac)(bc)	*(ab)(ac)(bc)
RDA		-	39.9	35	1685
11 - < 13 (N = 267)	NW (a) (n =139)	376.06 ± 48.04	46.14 ± 12.80	35.57 ± 7.57	2009.06 ± 203.80
	OW (b) (n = 82)	384.90 ± 44.12	53.89 ± 14.37	41.90 ± 11.38	2132.31 ± 219.74
	OB (c) (n = 46)	396.89 ± 53.34	58.96 ± 15.09	57.29 ± 18.03	2339.10 ± 254.51
F value		3.43	18.27	65.30	40.58
Level of significance		* (ac)	*(ab)(ac)	*(ab)(ac)(bc)	*(ab)(ac)(bc)
RDA		-	39.9	35	2190

Values are Mean ± SD

'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight categories. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected macronutrients among three body weight categories in each age group (* $p < 0.05$, ns = not significant). Sceffe's multiple comparisons test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'; NW = normal weight, OW = overweight, OB = obese

It is also noted from Table 9.1 that the mean value of protein intake was significantly ($p<0.05$) high in normal weight categories compared overweight and obese boys in all age groups, except 7 - < 9 and 9 - < 11 years age groups, where no significant difference was observed among three body weight categories. It was also observed from the Table 9.1 that the reported protein intakes of three weight categories in all age group were higher than RDA. On the other hand, reported fat and calorie intake in overweight and obese boys were higher than RDA value in all age groups.

9.3.2. Comparison of intake of different micronutrients (vitamins) among three body weight categories in four different age groups of boys

Comparisons of selected vitamins intakes among three body weight categories in each of the four age groups of boys are presented in Table 9.2

One way ANOA was performed to make an overall comparison of the selected vitamins among three body weight categories in each of the four age groups. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group. It is evident from the table 9.2 that vitamin A, ascorbic acid, vitamin B12 and folic acid were no significantly different among three weight categories in all age groups. Again vitamin D differed significantly ($p < 0.05$) between overweight and normal weight categories in 5 - <7, 7 - <9 and 9 - <11 years age groups.

9.3.3. Comparison of intake of different micronutrients (minerals) among three body weight categories in four different age groups of boys

Comparisons of selected minerals intakes among three body weight categories in each of the four age groups of boys are presented in Table 9.3

One way ANOA was performed to make an overall comparison of the selected minerals among three body weight categories in each of the four age groups. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories for particular age group.

Table 9.2. Comparison of different dietary intakes of micronutrients (vitamins) among three body weight categories of boys from four different age groups

Age groups (years)	Category	Vitamin A (retinol) (µg/day)	Ascorbic acid (mg/day)	Vitamin D (µg/day)	Vitamin B12 (µg/day)	Folic acid (µg/day)
5 - < 7 (N = 245)	NW (a) (n = 142)	363.92 ± 238.55	58.90 ± 29.98	12.57 ± 6.13	4.57 ± 3.88	157.75 ± 87.71
	OW (b) (n = 61)	325.24 ± 200.35	64.31 ± 28.57	9.97 ± 4.50	3.98 ± 3.30	147.47 ± 84.24
	OB (c) (n = 42)	340.18 ± 176.98	68.47 ± 30.86	9.60 ± 4.62	4.27 ± 3.51	155.72 ± 82.07
F value		0.712	1.94	7.44	0.576	0.307
Level of significance		ns	ns	*(ab)(ac)	ns	ns
RDA		400	40	15	0.2-1.0	100
7 - < 9 (N = 261)	NW (a) (n = 146)	548.71 ± 319.16	69.53 ± 29.34	12.43 ± 5.73	4.66 ± 3.95	161.18 ± 73.86
	OW (b) (n = 72)	509.46 ± 245.22	65.73 ± 28.75	10.56 ± 4.75	4.30 ± 4.14	166.95 ± 81.06
	OB (c) (n = 43)	496.33 ± 258.78	70.03 ± 30.78	10.45 ± 4.38	4.43 ± 3.89	178.73 ± 88.77
F value		0.767	0.466	4.24	0.214	0.84
Level of significance		ns	ns	*(ab)	ns	ns
RDA		600	40	15	0.2-1.0	120
9 - < 11 (N = 263)	NW (a) (n = 146)	562.04 ± 295.95	75.32 ± 34.02	13.43 ± 6.76	4.75 ± 3.92	207.89 ± 135.81
	OW (b) (n = 63)	525.49 ± 235.31	71.85 ± 30.08	11.02 ± 4.90	4.39 ± 3.17	211.60 ± 139.39
	OB (c) (n = 53)	522.68 ± 239.86	77.89 ± 26.89	11.20 ± 4.88	4.50 ± 3.36	228.65 ± 153.53
F value		0.613	0.536	4.86	0.237	0.430
Level of significance		ns	ns	*(ab)	ns	ns
RDA		600	40	15	0.2-1.0	140
11 - < 13 (N = 267)	NW (a) (n =139)	553.25 ± 281.99	83.05 ± 41.30	13.22 ± 6.42	5.00 ± 4.43	192.24 ± 115.66
	OW (b) (n = 82)	535.54 ± 240.28	75.08 ± 28.42	11.22 ± 5.73	4.54 ± 3.80	199.91 ± 127.43
	OB (c) (n = 46)	534.02 ± 259.54	79.09 ± 30.41	11.37 ± 5.23	4.59 ± 3.66	216.33 ± 134.89
F value		0.158	1.28	3.87	0.381	0.670
Level of significance		ns	ns	*(ab)	ns	ns
RDA		600	40	15	0.2-1.0	140

Values are Mean ± SD

'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight categories. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected micronutrients (vitamins) parameters among three body weight categories in each age group (* $p < 0.05$, ns = not significant). Sceffe's multiple comparisons test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'; NW = normal weight, OW = overweight, OB = obese

It is noted from the Table 9.3 that dietary intakes iron and calcium were not significantly different among three body weight categories in all age groups. It is also observed from the study that dietary intake of zinc was significantly ($p < 0.05$) different between obese and normal weight categories in all age groups except 11- <13 years age groups. It was also observed from the Table 9.1 that the observed zinc intakes of three body weight categories in all age groups were lower than RDA. It is also noted from the table that observed calcium intake was only higher in 5 – < 7 years age group than the recommended dietary allowances (RDA).

Table 9.3. Comparison of different dietary intakes of micronutrients (minerals) among three body weight categories of four different age groups of boys

Age group (years)	Category	Iron (mg/day)	Calcium (mg/day)	Zinc (mg/day)
5 - < 7 (N = 245)	NW (a) (n=142)	12.70 ± 5.33	554.60 ± 274.32	6.86 ± 3.45
	OW (b) (n=61)	12.37 ± 5.71	533.60 ± 267.60	5.86 ± 3.00
	OB (c) (n=42)	13.23 ± 6.33	517.02 ± 242.00	5.30 ± 2.70
F value		0.294	0.369	4.66
Level of significance		ns	ns	* (ac)
RDA		13	400	8
7 - < 9 (N = 261)	NW (a) (n=146)	15.45 ± 6.13	576.98 ± 267.31	7.76 ± 3.91
	OW (b) (n=72)	15.88 ± 5.98	570.30 ± 269.56	7.06 ± 3.55
	OB (c) (n=43)	16.95 ± 7.33	580.15 ± 294.69	6.11 ± 2.95
F value		0.941	0.02	3.55
Level of significance		ns	ns	* (ac)
RDA		16	600	9
9 - < 11 (N = 263)	NW (a) (n=147)	19.79 ± 7.60	761.43 ± 416.99	8.48 ± 3.75
	OW (b) (n=63)	21.29 ± 8.25	700.97 ± 306.96	7.24 ± 3.65
	OB (c) (n=53)	22.89 ± 8.92	735.29 ± 288.45	6.69 ± 3.43
F value		3.06	0.599	5.63
Level of significance		ns	ns	* (ac)
RDA		21	800	9
11 - < 13 (N = 267)	NW (a) (n=139)	21.40 ± 8.19	728.74 ± 309.93	8.26 ± 4.22
	OW (b) (n=82)	21.60 ± 8.84	711.35 ± 294.02	7.80 ± 4.62
	OB (c) (n=46)	24.23 ± 8.65	749.76 ± 301.76	7.74 ± 3.92
F value		2.02	0.241	0.41
Level of significance		ns	ns	ns
RDA		21	800	9

Values are Mean ± SD

'N' indicates total no of subjects in each age group and 'n' indicates the number of subjects in each body weight categories. One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected micronutrients (minerals) among three body weight categories in each age group (* $p < 0.05$, ns = not significant). Sceffe's multiple comparisons test was performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c' (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'. NW = normal weight, OW = overweight, OB = obese

9.3.4. Determination of relationship of BMI and body fat% with selected nutritional parameters

Table 9.4 represents the relation of BMI and body fat% with selected nutritional parameters. It is revealed from the Table 9.4 that dietary intake carbohydrate, protein, fat; calorie and iron were significantly ($p < 0.001$) and positively correlated with BMI and body fat%. On the other hand dietary intake vitamin D was significantly ($p < 0.01$) negatively correlated with the BMI and body fat%.

9.3.5. Determination of relationship of SBP and DBP with selected nutritional parameters

Table 9.5 demonstrated the relation of SBP and DBP with selected nutritional parameters. It is observed from the Table 9.5 that dietary intakes of carbohydrate, protein, fat; calorie and iron, vitamin A were significantly and positively correlated with SBP and DBP. It is also evident from the table among dietary intakes of minerals only calcium was significantly and negatively correlated with the resting blood pressure.

9.3.6. Determination of relationship of selected motor quality parameters with selected nutritional parameters.

Pearson product-moment correlation coefficients between motor quality parameters with selected nutritional parameters were presented in Table 9.6 to 9.9. It is evident from the Table 9.6 that a significant negative correlation existed between nutritional parameters with hand reaction time (HRT) and foot reaction time (FRT). Similarly the speed of movement (SOM) and agility were significantly and negatively correlated with nutritional parameters (Table 9.7). A positive correlation was found between agility and dietary fat although no significance was obtained. On the other hand, Table 9.8 represents relation of

30 meters sprint with selected nutritional parameters. It is evident from the table that the values 30 meters sprint were significantly and negatively correlated with all selected nutritional parameters. Table 9.9 demonstrates the relation between nutritional parameters with VJT and SLJT. It is evident from the tables that the values of vertical jump test (VJT) and standing long jump test (SLJT) were positively and significantly correlated with the all the nutritional parameters .

Table 9.4. Pearson's Product moment correlation coefficient of BMI and FAT % with selected nutritional parameters

Variables	BMI (kg. m^{-2}) (N = 1036)			Body fat % (N = 1036)		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
Carbohydrate (gm/day)	0.419	0.367 to 0.468	P< 0.001	0.352	0.297 to 0.404	P< 0.001
Protein (gm/day)	0.270	0.213 to 0.326	P< 0.001	0.212	0.153 to 0.269	P< 0.001
Fat (gm/day)	0.628	0.590 to 0.664	P< 0.001	0.569	0.527 to 0.609	P< 0.001
Calorie (Kcal/day)	0.554	0.511 to 0.595	P< 0.001	0.477	0.429 to 0.523	P< 0.001
Vit. A (µg/day)	0.047	-0.013 to 0.10	ns	0.036	-0.024 to 0.096	ns
Ascorbic acid (mg/day)	0.076	0.015 to 0.136	0.013	0.065	0.004 to 0.126	0.0344
Vit.D (µg/day)	-0.137	-0.196 to -0.077	P< 0.01	-0.137	-0.196 to -0.07	P< 0.01
Vit.B_{12} (µg/day)	-0.002	-0.063 to 0.058	ns	0.0002	-0.060 to 0.084	ns
Folic acid (µg/day)	0.103	0.043 to 0.163	0.0008	0.0880	0.027 to 0.014	0.044
Iron (mg/day)	0.255	0.197 to 0.311	P< 0.001	0.197	0.137 to 0.254	P< 0.01
Calcium (mg/day)	0.067	0.007 to 0.128	0.028	0.023	-0.037 to 0.084	ns
Zinc (mg/day)	-0.050	-0.116 to 0.010	ns	-0.071	-0.131 to 0.010	0.021
ns = not significance, 95 % CI = 95% confidence intervals						

Table 9.5. Pearson's Product moment correlation coefficient of SBP and DBP with selected nutritional parameters

Variables	SBP (mmHg) (N = 1036)			DBP (mmHg) (N = 1036)		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
Carbohydrate (gm/day)	0.312	0.256 to 0.366	p< 0.001	0.246	0.187 to 0.302	p< 0.001
Protein (gm/day)	0.249	0.191 to 0.035	p< 0.001	0.186	0.126 to 0.244	p< 0.01
Fat (gm/day)	0.328	0.273 to 0.382	p< 0.001	0.278	0.221 to 0.334	p< 0.001
Calorie (Kcal/day)	0.372	0.318 to 0.423	p< 0.001	0.299	0.243 to 0.354	p< 0.001
Vit. A (µg/day)	0.118	0.057 to 0.178	p< 0.01	0.100	0.039 to 0.160	0.0013
Ascorbic acid(mg/day)	0.062	0.001 to 0.122	0.045	0.036	-0.024 to 0.097	ns
Vit.D (µg/day)	-0.019	-0.080 to 0.041	ns	-0.014	-0.075 to 0.046	ns
Vit.B_{12} (µg/day)	-0.001	-0.062 to 0.059	ns	-0.009	-0.069 to 0.059	ns
Folic acid (µg/day)	0.036	-0.024 to 0.097	ns	0.035,	-0.025 to 0.096	ns
Iron (mg/day)	0.219	0.160 to 0.276	< 0.001	0.181	0.121 to 0.239	p< 0.01
Calcium (mg/day)	-0.09	-0.117 to 0.003	0.024	-0.136	-0.16 to 0.095	p< 0.01
Zinc (mg/day)	0.016	-0.015 to 0.076	ns	0.008	-0.052 to 0.069	ns
ns = not significance, 95 % CI = 95% confidence intervals						

Table 9.6. Pearson Product moment correlation coefficient of HRT and FRT with selected nutritional parameters

Variables	HRT(sec) (N = 1036)			FRT(sec) (N = 1036)		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
Carbohydrate (gm/day)	-0.175	-0.238 to -0.115	p< 0.01	-0.382	-0.433 to -0.329	p< 0.001
Protein (gm/day)	-0.237	-0.294 to -0.179	p< 0.001	-0.428	-0.477 to -0.377	p< 0.001
Fat (gm/day)	0.010	-0.050 to 0.071	ns	-0.156	-0.215 to -0.096	p< 0.01
Calorie (Kcal/day)	-0.166	-0.225 to -0.106	p< 0.01	-0.410	-0.459 to -0.358	p< 0.001
Vit.D (µg/day)	-0.037	-0.097 to 0.0239	ns	-0.097	-0.157 to -0.037	0.0016
Iron (mg/day)	-0.149	-0.208 to -0.089	p< 0.01	-0.340	-0.393 to -0.285	p< 0.001
Calcium (mg/day)	-0.139	-0.198 to -0.078	p< 0.01	-0.214	- 0.271 to -0.155	p< 0.001
Zinc (mg/day)	-0.129	-0.189 to -0.069	p< 0.01	-0.191	-0.249, -0.132	p< 0.001
ns = not significance, 95 % CI = 95% confidence intervals						

Table 9.7. Pearson's Product moment correlation coefficient of SOM and agility with selected nutritional parameters

Variables	SOM (sec) (N = 1036)			Agility (sec) (N = 1036)		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
Carbohydrate(gm/day)	-0.454	-0.501 to -0.405	p< 0.001	-0.233	-0.289 to -0.174	p< 0.001
Protein (gm/day)	-0.506	-0.550 to -0.460	p< 0.001	-0.348	0.401 to -0.294	p< 0.001
Fat (gm/day)	-0.278	-0.344 to - 0.221	p< 0.001	0.0113	-0.049 to 0.072	ns
Calorie (Kcal/day)	-0.509	-0.533 to -0.463	p< 0.001	-0.235	-0.292 to -0.177	p< 0.001
Vit.D (µg/day)	-0.084	-0.145 to -0.024	p< 0.05	-0.141	-0.200 to -0.081	p< 0.01
Iron (mg/day)	-0.357	-0.409 to -0.303	p< 0.001	-0.232	-0.289 to -0.174	p< 0.001
Calcium (mg/day)	-0.217	-0.274 to -0.158	p< 0.001	-0.169	-.0.227 to -0.109	p< 0.001
Zinc (mg/day)	-0.153	-0.212 to -0.092	p< 0.01	-0.188	-0.247 to -0.129	p< 0.001
ns = not significance, 95 % CI = 95% confidence intervals						

Table 9.8. Pearson's Product moment correlation coefficient of 30 meter sprint with selected nutritional parameters

Variables	30 meter sprint (sec) (N = 1036)		
	r	95% CI	Level of Significance
Carbohydrate (gm/day)	- 0.385	- 0.385 to - 0.332	p< 0.001
Protein (gm/day)	- 0. 439	- 0.487 to - 0.389	p< 0.001
Fat (gm/day)	- 0.106	- 0.106 to - 0.045	p< 0.01
Calorie (Kcal/day)	- 0.398	- 0.448 to - 0.345	p< 0.001
Vit.D (µg/day)	- 0.081	- 0.141 to - 0.020	0.012
Iron (mg/day)	- 0.273	- 0.329 to - 0.216	p< 0.001
Calcium (mg/day)	- 0.197	- 0.255 to - 0.137	p< 0.01
Zinc (mg/day)	- 0.200	- 0.258 to - 0.146	p< 0.01
ns = not significance, 95 % CI = 95% confidence intervals			

Table 9.9. Pearson's Product moment correlation coefficient of VJT and SLJ with selected nutritional parameters

Variables	VJT (cm) (N = 1036)			SLJ (cm) (N = 1036)		
	r	95% CI	Level of Significance	r	95% CI	Level of Significance
Carbohydrate (gm/day)	0.358	0.303 to 0.410	p< 0.001	0.381	0.328 to 0.432	p< 0.001
Protein (gm/day)	0.370	0.316 to 0.421	p< 0.001	0.399	0.346 to 0.449	p< 0.001
Fat (gm/day)	0.127	0.066 to 0.187	p< 0.01	0.182	0.123 to 0.241	p< 0.001
Calorie (Kcal/day)	0.369	0.315 to 0.420	p< 0.001	0.403	0.351 to 0.453	p< 0.001
Vit.D (µg/day)	0.077	0.169 to 0.138	0.012	0.077	0.017 to 0.138	0.0121
Iron (mg/day)	0.270	0.213 to 0.325	p< 0.001	0.284	0.227 to 0.339	p< 0.001
Calcium (mg/day)	0.183	0.124 to 0.242	p< 0.01	0.193	0.134 to 0.251	p< 0.01
Zinc (mg/day)	0.134	0.073 to 0.193	p< 0.01	0.160	0.100 to 0.219	p< 0.01
ns = not significance, 95 % CI = 95% confidence intervals						

9.3.7. Multiple linear regressions analysis of selected nutritional parameters on blood pressure

Multiple linear regression analysis was performed to see the independent relationship of blood pressure (i.e., SBP and DBP) with selected nutritional parameters (i.e., calorie, protein, fat, iron and calcium) and standard partial regression coefficients (β) have been presented for this purpose (Table 9.10 and 9.11). The models were controlled several factors. In multiple regressions analysis demonstrated (Table 9.10 and 9.11) that all selected nutritional variables were positively associated with the SBP and DBP except calcium, where calcium was negatively associated with the SBP and DBP. It is also obtained from the Table 9.10 that the SBP was significantly ($p<0.001$) and positively related with calorie and dietary fat when protein, iron and calcium were controlled.

Table 10 also demonstrated that dietary fat had strong independent significant ($p<0.001$) and positive relation with the systolic blood pressure (SBP). In contrary, it is also observed from the Table 9.11 that the DBP was significantly ($p<0.01$) and positively related with calorie and dietary fat when protein, iron and calcium were controlled. Table 10.1 also represented that calorie and dietary fat had strong independent significant ($p<0.01$) and positive relation with the diastolic blood pressure (DBP).

9.3.8. Multiple linear regressions analysis of selected nutritional parameters on motor quality parameters

Multiple linear regression analysis was performed to see the independent relationship of with motor quality parameters (i.e. HRT, FRT, agility, 30 meter sprint, VJT and SLJT) with selected nutritional parameters (i.e., calorie, protein, fat, iron, calcium and zinc) and standard partial regression coefficients (β) have been presented for this purpose (Table 9.12). The models were controlled several factors. In multiple regressions analysis demonstrated (Table 9.12) that all selected nutritional variables were negatively and independently associated with the time related motor quality variables (i.e., HRT, FRT, agility and 30 meter sprint where length related motor quality variables (i.e., VJT and SLJT) were positively associated with selected nutritional variables. It is also observed from the Table 9.12 that all the selected nutritional variables were significantly and negatively associated with the time related motor quality variables. On the other hand, Table 9.12 also demonstrated that all the selected nutritional variables were significantly and positively related with the length related motor quality variables.

Table 9.10. Multiple regression analysis of calorie, protein, fat, iron and calcium on systolic blood pressure (SBP)

Systolic blood pressure (SBP) is dependent variable									
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
Calorie	82.34	0.005	0.001	0.204	4.75	p < 0.001	40.6	p < 0.001	0.16
Protein		0.044	0.022	0.067	2.00	0.045			
Fat		0.110	0.031	0.138	3.58	p < 0.001			
Iron		0.106	0.038	0.084	2.75	0.006			
Calcium		- 0.002	0.001	- 0.059	- 2.02	0.043			

Table 9.11. Multiple regression analysis of calorie, protein, fat, iron and calcium on diastolic blood pressure (DBP)

Diastolic blood pressure (DBP) is dependent variable									
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance	F	Level of significance	R^2
		B	Std. Error	Beta (β)					
Calorie	46.61	0.004	0.001	0.151	3.41	p < 0.01	26.18	p < 0.001	0.11
Protein		0.021	0.023	0.032	0.93	0.350			
Fat		0.109	0.109	0.137	3.45	p < 0.01			
Iron		0.090	0.039	0.072	2.28	0.02			
Calcium		- 0.002	0.001	- 0.076	- 2.51	0.012			

9.4. Discussion

Childhood malnutrition is a major concern in developing countries. The present study was mainly based on comparative analysis of selected nutritional parameters among three body weight categories in 5 to 12 years old school going Bengali boys in West Bengal, India. The present study showed that the mean dietary intake carbohydrate, fat and calorie were significantly ($p<0.05$) higher in overweight and obese categories compared to normal weight categories in all age groups (Table 9.1). Reported protein intakes of three body weight categories were higher than RDA in all age groups. On the other hand, reported fat intake in overweight and obese boys was higher and lower in normal weight boys in all age groups than the RDA. Furthermore, the total calorie intake was higher in overweight and obese boys but lower in normal than the dietary guidelines (RDA). Among micronutrients, the absolute dietary intakes of vitamin A, calcium, vitamin D and zinc were lower than recommendations in all age groups (Table 9.2 & 9.3). Vitamin D, vitamin A and calcium intake may be a consequence of the low consumption of dairy products, as suggested in literature (**Ferna´ndez et al., 1996).**

Table 9.12. Multiple regression analysis of calorie, protein, fat, iron and calcium on HRT, FRT, agility, 30 meter sprint, VJT and SLJT

Independent Variable	Constant (A)	Unstandarzied coefficient B	Unstandarzied coefficient Std. Error	Standardized coefficient Beta (β)	t	Level of significance	F	Level of significance	R^2
Hand reaction time (HRT) is dependent variable									
Calorie	0.328	- 0.006	0.000	- 0.032	- 0.88	0.377	17.74	p < 0.001	0.80
Protein		- 0.001	0.000	- 0.167	- 4.66	p < 0.001			
Calcium		- 0.005	0.000	- 0.096	-3.12	0.002			
Iron		0.000	0.000	- 0.073	- 2.27	0.023			
Zinc		- 0.001	0.000	- 0.085	- 2.76	0.006			
Foot reaction time (FRT) is dependent variable									
Calorie	0.441	- 0.005	0.000	- 0.340	- 8.71	p < 0.001	78.01	p < 0.001	0.31
Protein		- 0.001	0.000	- 0.244	- 7.88	p < 0.001			
Fat		0.001	0.000	- 0.214	6.11	p < 0.001			
Calcium		- 0.001	0.000	- 0.185	- 6.62	p < 0.001			
Iron		- 0.005	0.000	- 0.109	- 4.12	p < 0.001			
Zinc		- 0.001	0.000	- 0.099	- 3.71	p < 0.001			
Agility is dependent variable									
Calorie	17.16	- 0.001	0.000	- 0.235	- 5.65	p < 0.001	47.91	p < 0.001	0.21
Protein		- 0.026	0.003	- 0.260	- 7.89	p < 0.001			
Fat		0.036	0.004	0.307	8.19	p < 0.001			
Calcium		0.000	0.000	- 0.102	- 3.62	p < 0.001			
Iron		- 0.026	0.006	- 0.141	- 4.72	p < 0.001			
Zinc		- 0.041	0.011	- 0.104	- 3.68	p < 0.001			
30 meter sprint is dependent variable									
Calorie	9.11	- 0.001	0.000	- 0.387	- 9.94	p < 0.001	78.86	p < 0.001	0.31
Protein		- 0.015	0.002	- 0.271	- 8.87	p < 0.001			
Fat		0.020	0.002	0.290	8.27	p < 0.001			
Calcium		0.000	0.000	- 0.098	- 3.71	p < 0.001			
Iron		- 0.013	0.003	- 0.120	- 4.30	p < 0.001			
Zinc		- 0.025	0.006	- 0.109	- 4.21	p < 0.001			
Vertical jump test (VJT) is dependent variable									
Calorie	8.649	0.007	0.001	0.343	8.36	p < 0.001	53.40	p < 0.001	0.23
Protein		0.105	0.016	0.210	6.43	p < 0.001			
Fat		- 0.135	0.022	- 0.222	- 6.02	p < 0.001			
Calcium		0.002	0.001	0.096	3.42	p < 0.001			
Iron		0.130	0.028	0.137	4.63	p < 0.01			
Zinc		0.114	0.057	0.056	2.01	0.04			
Standing long jump test (SLJT) is dependent variable									
Calorie	60.30	0.019	0.002	0.329	8.14	p < 0.001	60.09	p < 0.001	0.26
Protein		0.317	0.047	0.218	6.78	p < 0.001			
Fat		- 0.281	0.064	- 0.160	- 4.38	p < 0.001			
Calcium		0.007	0.002	0.099	3.62	p < 0.001			
Iron		0.365	0.080	0.133	4.56	p < 0.001			
Zinc		0.483	0.161	0.083	2.99	0.003			

In case of vitamin intake, there was no significant variation found among three body weight categories except vitamin D, where vitamin D intake was significantly higher in normal boys than in overweight boys. Increased energy intake and decreased energy expenditure are often observed as major causes of overweight and obesity **(Muazzez et al., 2008)**. Some authors have reported no difference in energy intake between obese and non-obese individuals (**Atkin & Davies, 2000; Troiano et al., 2000).** However, it is possible that self reports of dietary intake confound such findings **(Balaban and Silva, 2004)** and indeed **Strauss (1999)** claims that obese adults generally under report the amount they eat. On the other hand, **Fox (2004)** suggests that self reports are especially unreliable in children, particularly regarding less memorable eating, which may include incidental snacks. **Obarzanek et al. (1994)** revealed that body fatness is related to energy intake and expenditure in both black and white girls aged nine to ten years. Also, some studies **(Eck et al., 1992; Gazzaniga et al., 1993; Livingstone et al., 2001; Nicklas et al., 2003)** have reported a significant relationship between obesity and percent of energy from fat, while in the current study also found a significant relationship between obesity and energy intake. Low physical activity levels may have similar importance as excess energy intake **(Rodriguez & Moreno, 2006).**

It is evident from the study that BMI and body fat% were positively correlated with dietary intakes of carbohydrate, protein, fat, calorie, vitamin A, ascorbic acid, folic acid, iron and calcium (Table 9.4). It is also noted from the results that among nutrient intakes, carbohydrate, protein, fat, calorie, ascorbic acid folic acid were significantly correlated with BMI and body fat%. Most interestingly, vitamin D, folic acid and zinc were negatively correlated with the BMI and body%. Vitamin D deficiency prevails in epidemic proportions all over the Indian subcontinent, with a prevalence of 70%–100% in the general population. In India, widely consumed food items such as dairy products are rarely fortified with vitamin D **(Gupta, 2014)**. Indian socio-religious and cultural practices do not facilitate adequate sun exposure, thereby negating potential benefits of plentiful sunshine **(Gupta, 2014)**. **Tucker et al. (1997**) analysed the diet of 262 children (mean age 9.8 years) and found that energy intake as well as energy from fat were positively correlated with adiposity. Vitamin D deficiency has been reported as a risk factor for various diseases such as osteoporosis, autoimmune diseases, various types of cancer, and cardiovascular diseases **(Wang et al., 2008; Huh, 2008; Scragg et al., 1995). Al-Sultan et al. (2011)** conducted a study on a group of age- and gender-matched overweight-obese young and lean controls. They found vitamin D to be significantly higher in lean controls, and showed a significant decline in according to classes of obesity. However, study results showed that vitamin D is negatively associated with body mass index **(Al-Sultan et al., 2011).**

Present study also reveals that the blood pressure (i.e., SBP and DBP) positively correlated with the dietary intake of carbohydrate, protein, fat, calorie, vitamin A, ascorbic acid, folic acid, iron and zinc respectively. On the other hand blood pressure was negatively correlated with dietary intake of vitamin D, vitamin B12 and calcium (Table 9.5). It is also observed from the table that DBP were significantly and negatively correlated with calcium intake. **Rolf & Kaare (2000)** studied showed that the after correction for age, body mass index, alcohol and coffee consumption, physical activity, cigarette smoking, and vitamin D intake, there was a significant linear decrease in systolic and diastolic blood pressure with increasing dietary calcium intake in both sexes ($P < 0.05$). There was a negative association between calcium intake and blood pressure. However, although the effect of calcium on blood pressure appears to be small, calcium could have a significant effect on primary prevention of cardiovascular diseases. Several reviews addressed the issue of calcium ingestion and blood pressure**. Cuttle & Brittain (1990)** found that the evidence for a role of calcium in hypertension was suggestive. **Cappuccio et al. (1995)** concluded that there was negative association between dietary calcium intake and blood pressure. Whereas **Osborne et al. (1996)** firmly stated that dietary calcium plays an integral role in the maintenance of normal blood pressure and that an adequate intake may help reducing the risk of hypertension and coronary artery disease. It is also evident from the present study that there were significant and negative correlations between time related motor quality parameters (i.e., hand reaction time, foot reaction time, speed of movement, agility and 30 meters sprint) with different nutrient intakes (Table 9.6 to 9.8). Present study also reveals that length related motor quality parameters (i.e., standing long jump and vertical jump) were significantly and positively correlated with the selected nutritional parameters (Table 9.9). Moreover, multiple regression analysis shows that all the selected nutritional parameters had independent and significant association with selected motor quality parameters (9.12).

Among essential microelement in the human body, zinc is involved in many important physiological functions mainly associated with brain development. It is particularly indispensable for children during the growth period. Many studies have shown that zinc plays a role in promoting physical growth and the development of cognitive and motor skill in children **(Ozbek and Akman, 201**2; **Black, 2003).** The role of zinc in promoting growth and development during infancy, and even during the foetal period, has been deciphered. The majority of studies, which have investigated the association between nutrition and cognitive development, have focused on individual micronutrient, including omega-3 fatty acids, vitamin B12, folic acid, zinc, calcium iron, and iodine **(Ghosh et al., 2010 ; Gale et al., 2009; Shah & Sachdev, 2006; Summers et al., 2008)**. The evidence is more consistent from observational studies, which suggest these micronutrients to play important role in the cognitive and motor development of children **(Tamura et al., 2005).**

9.5. Conclusion

The results did provide evidence that there were significant differences in average daily intake of carbohydrate, calorie and fat among normal weight, overweight and obese boys aged 5 to 12 years. High calorie consumption increases the risk of being overweight and obese. It is also evident from this study that nutritional status is an important factor for the development of motor skill for these boys. Among micronutrients, the absolute intakes of vitamin A, calcium, vitamin D and zinc were lower than recommendations in three body weight categories in all age groups. Adequate dietary calcium and zinc are important for all of body weight categories for their normal maturation and growth. There is considerable evidence that increased calcium intake reduces tendency of developing high blood pressure. Therefore, negative correlation between calcium intake and blood pressure provides an added reason why boys should meet the recommended daily allowances for calcium. This arises the need to devise meaningful measures to develop a healthy lifestyle among school children by creating awareness about recommended level of balanced diet.

Childhood Obesity & Risk Factors for Coronary Artery Disease

Chapter X

10.1. Introduction

A sedentary lifestyle with a diet rich in carbohydrates, fats and less micronutrients during childhood leads to obesity. Coronary artery disease (CAD) risk is increased by major factors such as physical inactivity, obesity, hypertension, hypercholesterolemia, hyperuricemia and hyperglycemia **(Grundy et al., 1998).** Clinical signs of coronary artery disease tend not to appear until adulthood. Several studies have shown that the process of atherosclerosis starts early on in childhood **(Berensonet et al., 1998).** Risk factors during childhood such as raised cholesterol, higher BMI and body fat% have been shown to increase the risk of coronary artery disease and stroke in adulthood, as well as cause early signs of atherosclerosis (including coronary artery calcification, decreased arterial distensibility, and increased carotid intimal-medial thickness), **(Baker et al., 2007; Whincup et al., 2005; Smoak et al.; 1987).**

On the other hand, serum uric acid is an independent risk factor for gout and diabetes. Hyperuricemia is the major risk factor of symptomatic gout (**Singh et al., 2011**).The clinical significance of which has been identified as the development of various co-morbidities including gout, metabolic syndrome, coronary artery disease (CAD) and type 2 diabetes (**Rho et al., 2005, Zhu et al., 2007) .** The prevalence of prediabetes, defined as impaired fasting glucose or impaired glucose tolerance, is increasing in child population **(Li et al., 2009).** Prediabetes in children is associated with both an elevated risk of developing type 2-diabetes and cardiovascular risk profile **(Nguyen et al., 2010).** Impaired fasting glucose (IFG) in obese and overweight children is associated with increased intima-media thickness, a predictive factor that is associated with atherosclerosis **(Reinehr et al., 2006).** The mechanism behind impaired fasting glucose is not fully understood. It may be result of impaired insulin secretion that indicates β cell dysfunction and also increased hepatic glucose output **(Cali et al., 2008).** Recent studies have shown that in obese children some impairment of glucose homeostasis might already be present at fasting glucose concentrations below the threshold for impaired fasting glucose **(Maffeis et al., 2010; O'Malley et al., 2010).** In addition; impaired fasting glucose (IFG) in Indian children is rarely studied. Consequently, this study was implemented to estimate the prevalence of the pre-diabetic state impaired fasting glucose among normal weight, overweight and obese boys. The purpose of the present study was to determine the prevalence of hypercholesterolemia, hyperuricemia and hyperglycaemia in normal weight, overweight and obese boys aged 5 to 12 years, in three different district towns (Bankura, Paschim Medinipur and Purba Medinipur) of state of West Bengal, India.

10.2. Material and methods

The present study was carried-out in 442 healthy school going Bengali boys aged between five to twelve years. On the basis of BMI-age-boys Z-scores, boys were categorised in three sub-divisions such Normal weight, Overweight and Obese **(WHO, 2007)**. All the selected biochemical parameters (i.e., Serum total cholesterol, triglycerides, high density lipoprotein cholesterol, and low density lipoprotein cholesterol, total cholesterol to high density lipoprotein cholesterol ratio, blood glucose and uric acid) were determined by standard procedures which have been elaborately discussed in Chapter III.

10.3. Results

10.3.1. Descriptive statistics of selected biochemical parameters of three body weight categories in 5 to 12 years boys

Mean, standard deviation (SD) and range of selected biochemical parameters of normal weight categories, overweight categories and obese categories have been presented Table 10.1.

Normal weight boys

It is noted from the Table 10.1 that the mean total cholesterol (TC) of normal weight boys was 148.40 $mg.dl^{-1}$ (range 94.66 to 232.55 $mg.dl^{-1}$), triglycerides (TG) 82.66 $mg.dl^{-1}$ (range 18.33 to 79.9 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 38.40 $mg.dl^{-1}$ (range 18.33 to 79.7 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 93.46 $mg.dl^{-1}$ (range 50.22 to 171.72 $mg.dl^{-1}$), TC:HDLC 4.10 $mg.dl^{-1}$ (range 2.13 to 6.99), blood glucose 73.40 $mg.dl^{-1}$ (range 49.51 to 106.45 $mg.dl^{-1}$), uric acid 3.77 $mg.dl^{-1}$ (range 1.98 to 7.5 $mg.dl^{-1}$).

Overweight boys

Table 10.1 demonstrates that the mean total cholesterol (TC) of overweight boys was 166. 29 $mg.dl^{-1}$ (range 99.33 to 255.43 $mg.dl^{-1}$), triglycerides (TG) 93.72 $mg.dl^{-1}$ (range 30.54 to 164.55 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 34.97 $mg.dl^{-1}$ (range 16.64 to 67.75 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 112.56 $mg.dl^{-1}$ (range 45.85 to 201.82 $mg.dl^{-1}$), TC:HDLC 5.01 $mg.dl^{-1}$ (range 2.19 to 8.15), blood glucose 80.31 $mg.dl^{-1}$ (range 56.51 to 119.54 $mg.dl^{-1}$), uric acid 4.09 $mg.dl^{-1}$ (range 2.2 to 8.22 $mg.dl^{-1}$).

Obese boys

It is observed from the Table 10.1 that the mean total cholesterol (TC) of obese boys was 166.72 $mg.dl^{-1}$ (range 104.2 to 245.54 $mg.dl^{-1}$), triglycerides (TG) 108.08 $mg.dl^{-1}$ (range 54.44 to 175.5 $mg.dl^{-1}$), high density lipoprotein cholesterol (HDLC) 33.20 $mg.dl^{-1}$ (range 17.66 to 58.32 $mg.dl^{-1}$), low density lipoprotein cholesterol (LDLC) 111.90 $mg.dl^{-1}$ (range 56.51 to 185.48 $mg.dl^{-1}$), TC:HDLC 5.25 $mg.dl^{-1}$ (range 2.19 to 8.15), blood glucose 86.03 $mg.dl^{-1}$ (range 61.77 to 125.54 $mg.dl^{-1}$), uric acid 4.33 $mg.dl^{-1}$ (range 2.2 to 8.4 $mg.dl^{-1}$).

Table 10.1. Selected biochemical parameters of three body weight categories in 5 to 12 years boys

Biochemical parameters	Normal weight (n = 165)	Overweight (n = 145)	Obese (n = 132)
Total cholesterol (TC) ($mg.dl^{-1}$)	148.40 ± 28.27	166.29 ± 38.09	166.72 ± 34.26
Range	94.66 - 232.55	99.93 - 255.43	104.2 - 245.54
Triglycerides (TG) ($mg.dl^{-1}$)	82.86 ± 33.57	93.72 ± 31.19	108.08 ± 32.98
Range	27.66 – 178	30.54 - 164.55	54.4 - 175.5
HDL Cholesterol (HDLC) ($mg.dl^{-1}$)	38.40 ± 13.40	34.97 ± 10.05	33.20 ± 9.48
Range	18.33 - 79.7	16.64 - 67.75	17.66 - 58.32
LDL Cholesterol (LDLC) ($mg.dl^{-1}$)	93.46 ± 20.28	112.56 ± 32.92	111.90 ± 26.51
Range	50.22 - 171.72	45.85 - 201.82	56.09 - 185.48
TC:HDLC	4.10 ± 0.93	5.01 ± 1.31	5.25 ± 1.24
Range	2.13- 6.99	2.19 - 8.15	3.08 - 8.84
Blood glucose ($mg.dl^{-1}$)	73.40 ± 12.73	80.31 ± 15.24	86.03 ± 16.91
Range	49.51 - 106.45	56.51 - 119.54	61.77 - 125.54
Uric acid ($mg.dl^{-1}$)	3.77 ± 1.24	4.09 ± 1.46	4.33 ± 1.40
Range	1.98 - 7.5	2.2 - 8.2	2.2 - 8.4

Values are Mean ± SD; HDL, high density lipoprotein; LDL, low density lipoprotein; TC: HDLC = total cholesterol to high density lipoprotein cholesterol ratio

10.3.2. Frequency and percentage of children having normal and elevated blood lipid parameters of three body weight categories in 5 to 12 years boys

Distribution of normal and elevated blood lipid parameters of three body categories are listed in Table 10.2

Three body weight categories boys combined

It is evident from the Table 10.2 that among 442 boys, normal total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 75.79% (n = 335), 87.78 % (n = 338), 91.4% (n = 404), 77.60% (n = 343) and 70.36% (n = 311) respectively.

Further the study demonstrated that for elevated levels of total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 24.20% (n = 107), 12.21 % (n = 54), 8.59 % (n = 38), 22.39% (n = 99) and 29.63% (n = 131) respectively in combined categories.

Normal weight boys

It is noted from the Table 10.2 that among 165 normal weight boys, normal total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 90.30% (n = 149), 96.96 % (n = 160), 97.7% (n = 161), 93.93% (n = 155) and 91.51% (n = 151) respectively.

Table 10.2 demonstrated that for elevated levels of total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 9.6% (n = 16), 3.03% (n = 5), 2.42% (n = 4), 6.06% (n = 10) and 8.48% (n = 14) respectively in normal weight boys.

Overweight boys

Table 10.2 shows that among 145 overweight boys, normal total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 65.51% (n = 95), 86.69 % (n = 126), 87.58% (n = 127), 67.58% (n = 98) and 61.37% (n = 89) respectively. On the other hand, it is also noted from the Table 10.2 that for overweight categories, elevated total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 34.48% (n = 50), 13.10 % (n = 19), 12.41% (n = 18), 32.41% (n = 47) and 38.62% (n = 56) respectively

Table 10.2. Frequency (F) and percentage (%) of children having normal and elevated values of blood lipid parameters

Lipid parameters	*Cut-off values	Normal weight (n = 165)		Overweight (n = 145)		Obese (n = 132)		Combined (n = 442)	
		F	%	F	%	F	%	F	%
TC ($mg.dl^{-1}$)									
Normal	≤ 190	149	90.30	95	65.51	91	68.93	335	75.79
Elevated	> 190	16	9.6	50	34.48	41	31.06	107	24.20
TG ($mg.dl^{-1}$)									
Normal	≤ 150	160	96.96	126	86.89	102	77.27	388	87.78
Elevated	> 150	5	3.03	19	13.10	30	22.72	54	12.21
HDLC ($mg.dl^{-1}$)									
Normal	≥ 20	161	97.57	127	87.58	116	87.87	404	91.40
Elevated	< 20	4	2.42	18	12.41	16	12.12	38	8.59
LDLC($mg.dl^{-1}$)									
Normal	≤130	155	93.93	98	67.58	90	68.18	343	77.60
Elevated	>130	10	6.06	47	32.41	42	31.81	99	22.39
TC:HDLC									
Normal	≤ 5.5	151	91.51	89	61.37	71	53.78	311	70.36
Elevated	> 5.5	14	8.48	56	38.62	61	46.21	131	29.63

*Cut-off values based on according to the guidelines from **Khalil et al. (1995**) for lipid profile norms in Indian children

Obese boys

It is observed from the Table 10.2 that among 132 obese boys, normal total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 68.93% (n = 91), 77.27 % (n = 102), 87.87% (n = 116), 68.18% (n = 90) and 53.78% (n =71) respectively.

It is reported from the table that for obese boys, elevated levels of total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density cholesterol (LDLC) and total cholesterol to high density lipoprotein cholesterol ratio (TC:HDLC) were 31.06 % (n = 41), 22.72 % (n = 102), 12.12% (n = 16), 31.81% (n = 42) and 46.21% (n = 61) respectively.

10.3.3. Frequency and percentage of children having normal and elevated fasting blood glucose and uric acid of three body weight categories in 5 to 12 years boys

Distribution of normal and elevated blood glucose and uric acid of three body categories are presented in Table 10.3.

Three body weight categories boys combined

Table 10.3 demonstrated that among 442 boys, results for normal blood glucose and uric acid were 92.76% (n = 410) and 86.19 (n = 381) respectively. On the other hand, elevated levels of blood glucose and uric acid were 7.23% (n = 32) and 13.80 % (n = 61) respectively in selected combined population.

Normal weight boys

In normal weight children, normal blood glucose and uric acid were detected in 100% (n = 165) and 92.72% (n = 153) respectively (Table 10.3). In contrary, elevated levels of blood glucose and uric acid were 0.0 % (n = 0) and 7.27 % (n = 12) respectively in normal weight categories (Table 10.3).

Overweight boys

Table 10.3 demonstrated that normal blood glucose and uric acid were detected in 91.72 (n = 133) and 85.51 % (n = 124) respectively. On the other hand, elevated levels of blood glucose and uric acid were 8.27% (n = 12) and 14.48 % (n = 21) respectively in overweight categories.

Obese boys

In obese boys, normal blood glucose and uric acid were detected in 84.4% (n = 112) and 78.78% (n = 104) respectively (Table 10.3). On the other hand, elevated levels of blood glucose and uric acid were 15.15 % (n = 32) and 21.21 % (n = 28) respectively in obese boys (Table 10.3).

Table 10.3. Frequency (F) and percentage (%) of children having normal and elevated values of fasting blood glucose and uric acid

Biochemical parameters	*Cut-off values	Normal weight (n = 165)		Overweight (n = 145)		Obese (n = 132)		Combined (n = 442)	
		F	%	F	%	F	%	F	%
Blood glucose									
Normal	≤ 110	165	100	133	91.72	112	84.84	410	92.76
Elevated	110 >	0	0.0	12	8.27	20	15.15	32	7.23
Uric acid									
Normal	≤ 7	153	92.72	124	85.51	104	78.78	381	86.19
Elevated	> 7	12	7.27	21	14.48	28	21.21	61	13.80

*Cut-off values based on guidelines from **Soldin et al. (1999)**

10.4. Discussion

Among combined boys, 24.20%, 12.21 %, 8.59%, 22.39 %, and 29.63% showed higher level of total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density lipoprotein cholesterol (LDLC), total cholesterol to high density lipoprotein cholesterol (TC:HDLC) ratio respectively than normal values (Table10.2). In this analysis, 24.20% of combined children aged 5–12 years had high total cholesterol. This result is helpful to monitor abnormal cholesterol levels among children public health interventions to promote long-term cardiovascular health and coronary artery disease in adulthood. We also observed that 7.23% and 13.80% of the combined boys had higher values of blood glucose and uric acid respectively than in normal (Table 10.3).

It is also notable from the present study that 34.48%, 13.10%, 12.41% and 32.41% of overweight boys had high total cholesterol (TC), triglycerides (TG), high density lipoprotein (HDLC) and low density lipoprotein cholesterol (LDLC) which is considered a potent risk factor of coronary artery disease as abnormal lipid profile **(Cobayaschi et al., 2010)**. In this study, 38.62 % of the overweight boys had higher than recommended total cholesterol to high density lipoprotein cholesterol ratio (TC: HDLC) in comparison to only 8.48% of the normal weight boys.

When the total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLC), low density lipoprotein cholesterol (LDLC) and TC: HDLC levels were analyzed separately, prevalence of the coronary artery disease risk were 31.06%, 22.72%, 12.12%, 31.81% and 46.21 % respectively for the obese boys, in comparison to 9.6% , 3.03% , 2.42%, 6.06% and 8.48% respectively among normal weight boys. Coronary heart disease risk is increased by major factors such as high total cholesterol, triglycerides, low density lipoprotein protein cholesterol and lower level of high density lipoprotein cholesterol. A large number of overweight and obese boys presented with abnormal lipid profiles.

Altogether in the boys of all age groups (combined) 24.5% had high total cholesterol, which is greater than the rates found in American children as reported by **Kit et al. (2015).** Having a minimum of 3 risk factors (hypercholesterolemia, TC: HDLC, serum uric acid) puts these boys at a much higher risk for coronary artery disease (CAD). High total cholesterol (TC) has been cited as an independent risk factor for coronary artery disease (CAD), and has been associated with atherosclerotic lesions starting early in adolescence **(Newman et al., 1991).** On the other hand, fasting serum low density lipoprotein cholesterol (LDLC) is regarded as the strongest predictor of cardiovascular risk and has been associated with early signs of atherosclerosis such as calcification and fatty streaks in the arteries **(Newman et al., 1991, Boyd et al., 2005)**. In addition, high fasting serum triglycerides have also been regarded as a risk factor for heart disease and have been shown to be associated with premature vascular age in overweight and obese boys **(Le et al., 2010**).

It is also evident from the study that abnormal uric acid were 21.12 % and 14.48 % in obese and overweight boys respectively (Table 10.3). **Masaru et al. (2011)** in an investigation on hyperuricemia in children and adolescent with obesity or various paediatric disorders showed that among 328 children, 19.4% were found to have hyperuricemia in obese boys. Epidemiological studies have demonstrated a close relationship between serum uric acid levels and the presence of metabolic syndrome (high fasting glucose, hypertriglyceridemia, low high density lipoprotein cholesterol, high low density lipoprotein cholesterol) among children and adolescents as well as adults **(Ford et al., 2007).** Some studies have even noted the strong association between carotid atherosclerosis and serum uric acid among obese children (**Ford et al., 2007; Pacifico et al., 2009, Zhang et al., 2012)**. One study analyzed the cross-sectional data of 1,370 US children and adolescents from the National Health and Nutrition Examination Survey (NHANES) 1999 to 2002 and found a positive association between serum uric acid and abdominal obesity. Another evidence, suggests that higher level uric acid determines the development of obesity, hypertension and type II diabetes mellitus **(Rathmann et al., 1998; Oyama et al., 2006).**

It has been shown that children with overweight and obesity are at increased risk of abnormal fasting blood glucose compared to normal weight boys **(Baranowski et al., 2006; Duncan, 2006; Williams et al., 2005)**. The prevalence of abnormal fasting blood glucose in overweight and obese boys was 14.48% and 21.21%, respectively. Interestingly, study from another researcher in Sweden recently reported marked differences in fasting blood glucose prevalence in children suffering obesity in Austria, which seems to confirm our results **(Ciba et al., 2015).**

A fasting lipid profile is the recommended approach to cholesterol screening, because there is currently no non invasive method to assess atherosclerotic cardiovascular disease in children aged 5 to 12 years. Our study suggests that paediatric screening for lipid parameters, fasting blood glucose and uric acid in children has a crucial predictive value for development of coronary artery disease in future, especially serum total cholesterol, triglyceride and LDLC. Given the even higher prevalence of hypercholesterolemia, hyperuricemia, hypertriglyceridemia and hyperglycaemia in the present sample, significance is obtained for screening overweight and obese Bengali children aged five to twelve's years.

10.5. Conclusion

Selected coronary artery disease risk factors are highly prevalent among boys with overweight and obese aged 5 to 12 years in West Bengal. On the other hand, the prevalence of fasting serum uric acid and blood glucose had higher in overweight and obese boys compared to normal weight categories. Based on the results of the study, it concludes that in order to reduce these coronary artery disease risk factors, Bengali overweight and obese children need to be screened. This is an effective and easy method of prevention and should be employed by children's physicians in routine health checkups. Many researchers have shown that early intervention is main key to preventing coronary artery disease **(Liann et al., 2010; Baker et al., 2007; Lawet et al., 1994).**

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Obesity, Motor Quality and Physiological Developement Among Urban Preadolescent Children From Midnapore, India

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Abstract: *In present time obesity has attained a major focus of research as one of the nutritional problems in developed and developing countries. In India this number is increasing day by day due to changing life style in all age group. In this study the prevalence of overweight and obesity were estimated from 105 school going Bengali preadolescent children from middle income-group urban families of Midnapore town, West Bengal, India. They were divided into control, overweight and obese group of each sex according to the respective BMI percentile value. Anthropometric variables, physiological variables, and several motor quality variables were measured. Result obtained revealed that the prevalence of obesity was 18.8% among boys and 23% among girls. The obese group showed increased value of anthropometric parameters. There were significant differences of all of the variables in between control, overweight and obese girls and boys except hand grip strength of both sexes and standing long jump of boys. Product moment correlation showed all variables were significantly correlating with BMI and % of fat. Obese girls were showing higher values of anthropometric parameters and lower values of physiological and motor parameters in comparison with obese boys. Thus this developing urban community is in a growing concern for their growing proportion of obese individual as they are under a substantial handicap in physical performance.*
Keywords: *Obesity, BMI, Motor Quality, Respiratory Fitness*

I. Introduction

Accumulation of excess fat in the body is termed as obesity. Although a number of factors contributing to the development of obesity are well established, the etiology of obesity is not exactly clear (Tucker et al. 1997). Watanabe et al. (1994) observed obesity to a large extent as the result of physical inactivity with the maintenance of an abundant and frequently high fat diet. Incidences of childhood obesity have been increasing since 1980s (Han et al. 2010).The children in developing countries suffering from double forms of malnutrition. Urban children are afflicted with problems of over-nutrition while rural and slam children suffer from effects of under nutrition (Chatterjee et al. 2002). According to Bessesen (2008), 10% of children worldwide are either overweight or obese. 50-80% of obese preadolescent children will grow up to become obese adults (Styne et al. 2001).

Childhood obesity is associated with several risk factors for the development of heart diseases and other chronic problems including hyperlipidemia, hyperinsulinemia, hypertension and early atherosclerosis (Berenson et al. 1993; 1998, Cole et al. 2000). The correlation of childhood obesity to adulthood diseases is of major concern (Chatterjee et al. 2006) as it because harder to treat obesity in adults than in children (Park et al. 2005). So effective prevention of adult diseases due to obesity will require the prevention and management of childhood obesity (WHO, 2000).

Selected body measurements like stature, mass, various skinfold thicknesses and other body dimensional measurements have globally been accepted as sensitive indicators of growth progress and nutritional status of children and the growing population.(Pakrasi et al. 1986; Chatterjee et al. 1993) In order to develop an internationally acceptable definition of obesity, Cole et al .(2000) scientifically specified cut-off points of BMI, a ratio of body mass and stature which are the two most easily measurable parameters, for categorizing children as obese in an age-wise pattern.

As excessive body weight affects body geometry and increases the mass of different body segments, there is obstruction in different physiological, aerobic and motor response in those over weight and obese children in same physiological conditions. This changing trend in body weights in children is important for public health policy. The objective of this study was to determine the prevalence of obesity in a representative sample of urban preadolescent school going children from the Midnapore town, West Bengal, India. The other objective was to correlate several physiological, aerobic and motor quality variables of obese among non obese subjects.

II. Materials AND Methods

Selection of Subjects:

This cross sectional investigation was undertaken with 105 (53 boys and 52 girls) school going healthy children between the ages 10 to 12 years from middle socioeconomic class (ICMR Technical Report, 1972) Bengali families. The age of each subject was calculated from the date of birth as recorded in their school register. The children were randomly sampled from different schools of Midnapore town, West Bengal, India. Each child underwent a one-day testing session. During this session, anthropometric assessments and other tests were carried out (Comitato. 1988, Council of Europe, 1983).

Measurement of Anthropometric parameters

Measurement of Height and Weight:

Height was measured in the upright position to the nearest millimeter and body mass was determined using a balance with a 100-gm minimum detectable limits (Cole et al. 2000).

Determination of BMI:

BMI were calculated according to the method mentioned by Meltzer et al (1988). The obese and overweight children were separated from the non-obese according to the international cut off points of BMI as proposed by Cole et al. (2000) and also following the guidelines of WHO. Among boys, 29 were normal weight, 14 overweight and 10 obese. Among girls, 26 were normal weight, 14 overweight and 12 obese. The underweight boy and girls were excluded from my study.

Measurment of skinfold thickness:

The skinfold measurements included the triceps, sub-scapular chest, abdomen, mid-thigh and calf were taken on the right side of the body with the children standing in the proper upright posture according to methods proposed by Johnson et al. (1988) using a calibrated skinfold caliper with constant tension (Norton et al. 1996). Obesity was further confirmed by the fat percent value as proposed by Watanabe et al. (1994).

Measurement of physiological parameters

Determination of aerobic capacities:

Children were asked to take complete rest for half an hour before performing the exercise so that pulmonary ventilation and pulse rate might come down to a steady state. The Queen's College Step Test (QCT) which has been recommended as a valid and reliable indirect method for prediction of Vo_{2max} (Chatterjee et al. 2001) was adopted in the present investigation. In brief, the step test was performed using a stool of 16.25 inches (or 41.30 cm) height. Stepping was done for a total duration of 3 minutes at the rate of 24 cycles per minute. After completion of the exercise, the subjects were asked to remain in standing posture comfortably and the carotid pulse rate was measured from the fifth to the twentieth second of the recovery period. This 15 second pulse rate was converted into beats per minute and the following equation was used to predict Vo_{2max}. **Vo_{2max} (ml/kg/min) = 111.33 – (0.42 × pulse rate in beats per min)** for boys and = 65.81 – (0.1847 X **pulse rate in beats per min)** for girls**.** All experiments were performed at a room temp varying from 27–29°C and at a relative humidity ranging between 70 and 85% (Mcardle, 2001).

Measurement of respiratory rate :

Respiratory rate was measured according to the method mentioned by Simoes et al. 1991.

Measurement of motor quality variables

Measurement of standing long jump:

Children were made standing behind a line marked on the ground with feet slightly apart. A two foot take-off and landing was used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempted to jump as far as possible, landing on both feet without falling backwards. Three attempts were allowed. The measurement was taken from take-off line to the nearest point of contact on the landing (back of the heels). The longest distance was recorded (Ward et al. 2005).

Measurement of handgrip strength :

A calibrated hand dynamometer with adjustable grip was used. Children were asked to hold the dynamometer in their both hand, at their side without touching the rest of the body, and squeeze it forcefully keeping the instrument held in line with the forearm during the duration of the test. Children were required to squeeze gradually and continuously for at least 2 seconds. The best result was the score recorded in kilograms (Ignacio et al. 2007).

Determination of hand reaction time :

The children sited on a chair with such a height that their forearm was in comfortably resting position. The tips of the thumb and index finger were held in a ready to pinch position about 3 or 4 inches beyond the edge of the table. The upper edge of the thumb and index finger were in a horizontal position. The tester holds the stick timer near the top, letting it hang between the subject's thumb and index finger. The children were directed to look at the stick and were told to react by catching the stick when it was released. The children were not allowed for locking at the tester's hand; nor were they allowed to move their hand up or down while attempting to catch the falling stick (Johnson et al. 1974). The children were allowed for ten times.

Determination of running speed:

A 10x2 m shuttle running and turning test at maximum speed were conducted for all students. Two parallel lines were drawn on the floor separated by 5 meter. Both feet of the child had to cross the line each time. The time needed to complete two cycles (back and forth) was recorded as the final score. All children were motivated to run as fast as they could (Ignacio et al. 2007).

Statistical analysis:

Descriptive statistics were run on all variables. One way ANOVA was performed to study the existence of significance in the difference of means of variables among different subject groups. Further Scheffe's multiple comparison analysis was conducted. Pearson's product moment correlation was adopted to establish the relationship between variables. Unpaired two tail t-test was performed to test significance of difference between the means of variables between boys and girls.

III. Result AND Discussion

Table-1 & 2 represents the mean values and standard deviations of all variables. The obese and overweight individuals were observed have higher values of body mass comparing with normal individuals. The girls were found to have higher mean values of weight, BMI, percent of fat than boys. Many paper reported significantly higher values for body mass in all sexes in obese group as also observed in the present study and this is accredited to the excess accumulation of fat mass among obese individuals (Buskirk et al. 1974). Mean stature and body mass data for non-obese preadolescent corroborate with the previous study in rural boys of West Bengal (Chatterjee et al. 1993). BMI was significantly higher among obese children because of the significantly higher body mass when compared to non-obese children. Mean BMI values for all ages further establish the relevance of proper categorization of children into obese and non-obese groups with respect to the primary aim of the current study. In relation to gender, national published data showing that boys have almost double the prevalence of obesity than girls at the age of 6 to 9 years. However, in agreement with data previously published (**Moreno et al. 2001**), our results indicate opposite findings, as illustrated by the significantly lower proportion of obese boys (18.8%) in relation to obese girls (23%). A study from Delhi reported the prevalence of obesity as 7.4% (WHO 2002), While another study done in school children in Punjab reported prevalence of overweight and obesity to be 11.1% and 14.2% respectively (Chhatwal et al. 2004). A study conducted in Pune documented the prevalence of obesity 5.7% and overweight 19.9% (Khadikar et al., 2004)

Table:1 Comparison of anthropometric, physiological and motor quality variables of boys.

Variables		Boys		
	Normal(a)(N-29)	Overweight(b)(N-14)	Obese(c)(N-10)	LS
Wt.(Kg)	27.72±0.37	36.00±0.35	44.20±1.90	**(ab)(bc)(ca)
BMI(kg/m2)	14.86±0.19	19.09±0.26	23.15±1.04	**(ab)(bc)(ca)
Fat %	8.44±0.23	11.27±0.48	16.78±1.39	**(ab)(bc)(ca)
LBM	26.64±0.37	33.92±0.48	39.09±1.72	**(ab)(bc)(ca)
VO_2max(ml/kg/m)	41.02±0.31	39.92±0.26	40.00±0.31	*(ab)
RR(c/m)BF	21.20±0.37	21.64±0.31	20.80±0.32	ns
RR(c/m)AF	38.45±0.85	39.46±1.20	41.25±1.40	*(bc)(ac)
SLJ(cm)	139.95±1.43	142.22±1.60	136.50±2.29	ns
HGS(kg)R	12.31±0.53	15.07±0.72	13.60±1.01	ns
HGS(kg)L	11.72±0.42	13.78±0.52	11.70±0.76	ns
HRT(sec)	0.16±0.02	0.15±0.01	0.18±0.02	**(bc)(ac)
TRST(sec)	8.99±0.21	9.01±0.18	10.04±0.28	**(bc)(ac)

Table:2 Comparison of anthropometric, physiological and motor quality variables of girls.

Variables	Girls			
	Normal(a)(N-26)	**Overweight(b)(N-14)**	**Obese(c)(N-12)**	**LS**
Wt.(Kg)	30.60±0.44	41.71±0.80	48.91±2.09	**(ab)(bc)(ca)
BMI(kg/m2)	17.30±0.14	21.33±0.36	26.81±0.83	**(ab)(bc)(ca)
Fat %	11.90±0.56	14.40±0.58	21.57±0.78	**(ab)(bc)(ca)
LBM	23.20±0.58	31.39±0.47	34.79±1.21	**(ab)(bc)(ca)
VO_2max(ml/kg/m)	40.75±0.25	40.10±0.21	38.21±0.26	*(bc)(ac)
RR(c/m)BF	21.10±0.31	21.00±0.27	18.21±0.41	ns
RR(c/m)AF	37.50±0.84	38.05±1.20	38.45±1.24	*(ab)(ac)
SLJ(cm)	138.00±1.60	141.91±1.77	133.29±2.57	**(bc)
HGS(kg)R	11.10±0.49	11.57±0.54	12.25±0.53	ns
HGS(kg)L	10.40±0.47	10.35±0.57	10.83±0.34	ns
HRT(sec)	0.15±0.02	0.14±0.02	0.17±0.01	**(ab)(bc)
TRST(sec)	8.70±0.19	9.46±0.24	10.26±0.29	**(ab)(ac)

LBM-Lean Body Mass, RR-Respiratory Rate, SLJ-Standing Long Jump, HGS-Hand Grip Strength, HRT-Hand Reaction Time. Values are ±SEM, One way ANOVA was performed to compute the means, *$p<0.05$, **$p<0.01$, ns-not significant, Scheffe's multiple comparison test was performed between group a,b,c/ab-aVb,p<0.05;bc-bVc,p<0.05;ac-aVc,p<0.05.

Analysis of the association between BMI and physiological and motor variables in preadolescent children revealed that as the BMI values increased physiological and motor quality variable decreased. Similar findings have been reported earlier (Kelishadi et al. 2003; Flodmark et al. 2006; Moayeri et al. 2006). For preadolescent children, not only motor activities are important, aerobic fitness can also be used as a good predictor for some incoming health risks like hyperinsulinemia, hypercholesterolemia, and others in future (Gutin et al. 2004; 2005). Our result are in agreement with several studies showing that respiratory fitness levels in preadolescents are low and that fitness can be used to detect those children with enhanced risk of cardiovascular disease (Ortega et al. 2005; 2007; Gutin et al. 2005).

In this study we observed there is no significant difference in Vo_{2max} in overweight and normal weight group. But there is significantly low value of Vo_{2max} in obese group as compared to both sexes. This probably indicates that ability to perform exhausting work is less in obese individuals. Buskirk et al. (1957), Chatterjee et al. (2005) also observed similar results. A lower Vo_{2max} indicate the oxygen consumption per unit of body mass was significantly less in the obese group. This is probably because of the excessive amount of body fat that appeared to exert an unfavorable burden as well as hindering action towards cardiac function, particularly during exhausting exercise when excessive hyperactive body musculature fails to uptake sufficient amount of oxygen due to deposition of proportionately high amount of fat mass.

According to Table-3, strong positive correlation to all variables with BMI and lean body mass was observed. Similar results were found in study reported by Welch (1957), Buskirk and Taylor (1957), Chatterjee (2005). Our purpose of the study was to investigate gross motor skill in overweight and obese children in comparison with normal-weight children. The inverse relationship between motor skill competence and body weight is often explained from a mechanical point of view, because obesity influences body geometry and increases the mass of different body segments. As children with movement difficulties perceive themselves less competent than other children, they are less likely to be physically active and they show preference for sedentary pastime (Bouffard et al. 1996; Cairney et al. 2005; 2006). Such an activity deficit may however strengthen their lack of motor skill. Table-4 represents the comparison of different variables between controls, overweight and obese boys and girls and it was observed that anthropometric parameters have significantly higher values in obese girls. On the other hand physiological and motor quality variables have lower values in obese girls in comparison with obese boys.

Table:3 Product-moment correlation coefficients of BMI and % of Fat with different variables.

Variables	Boys		Girls	
	BMI	Fat%	BMI	Fat%
VO_2max(ml/kg/m)	*	*	*	*
RR(c/m)BF	*	*	*	*
RR(c/m)AF	**	*	**	*
SLJ(cm)	**	*	**	**
HGS(kg)R	*	*	*	*
HGS(kg)L	*	*	*	*
HRT(sec)	**	**	*	**
TRST(sec)	**	*	***	***

* P< 0.0; ** P<0.01:***P<0.001

Table:4 Comparison of different variables of control, overweight, obese boys and girls.

Variables	Normal			Overweight			Obese		
	Boys	Girls	LS	Boys	Girls	LS	Boys	Girls	LS
Wt.(Kg)	27.72±0.37	30.60±0.44	ns	36.00±0.35	41.71±0.80	*	44.20±1.90	48.91±2.09	**
BMI(kg/m2)	14.86±0.19	17.30±0.14	ns	19.09±0.26	21.33±0.36	*	23.15±1.04	26.81±0.83	**
Fat %	8.44±0.23	11.90±0.56	**	11.27±0.48	14.40±0.58	**	16.78±1.39	21.57±0.78	**
LBM	26.64±0.37	23.20±0.58	ns	33.92±0.48	31.39±0.47	**	39.09±1.72	34.79±1.21	*
VO2max(ml/kg/m)	41.02±0.31	40.75±0.25	ns	39.92±0.26	40.10±0.21	ns	40.00±0.31	38.21±0.26	**
RR(c/m)BF	21.20±0.37	21.10±0.31	ns	21.64±0.31	21.00±0.27	ns	20.80±0.32	18.21±0.41	*
RR(c/m)AF	21.20±0.37	37.50±0.84	ns	21.64±0.31	38.05±1.20	ns	20.80±0.32	38.45±1.24	*
SLJ(cm)	139.95±1.43	138.00±1.60	ns	142.22±1.60	141.91±1.77	ns	136.50±2.29	133.29±2.57	*
HGS(kg)R	12.31±0.53	11.10±0.49	ns	15.07±0.72	11.57±0.54	*	13.60±1.01	12.25±0.53	ns
HGS(kg)L	11.72±0.42	10.40±0.47	ns	13.78±0.52	10.35±0.57	*	11.70±0.76	10.83±0.34	ns
HRT(sec)	0.16±0.02	0.15±0.02	ns	0.15±0.01	0.14±0.02	ns	0.18±0.02	0.17±0.01	ns
TRST(sec)	8.99±0.21	8.70±0.19	ns	9.01±0.18	9.46±0.24	ns	10.04±0.28	10.26±0.29	ns

Data are presented as mean; LS-Level of Significance;*p<0.05;**p<0.01

Evidences from several national health surveys in Asia points to significant differences in prevalence of overweight and obesity among countries (Ge et al. 1997; Ko et al. 1997; Yoshiike et al. 1998; Aekplakorn et al. 2004; Griffiths et al. 2001). Asian countries such as Taiwan and China have experienced rapid increases in prevalence of childhood obesity (Chu et al. 2005; Wu et al. 2006). Rapid economic growth has improved the nutritional, socioeconomic and health status of those countries (WHO 2003). Obesity has increased markedly with this nutritional evolution in most Asian countries (Popkin et al. 1998). A similar nutritional transition is under way in India (Griffiths et al. 2001). In addition to the nutritional and socioeconomic transitions, the behavioral transition of children is also possibly contributing significantly to the rapidly rising prevalence of obesity. Unhealthy eating habits and physical inactivity are the major culprits (Bar et al. 1998). The sedentary lifestyle of children and adolescents have been attributed mainly to television viewing, computer games, internet, overemphasis on academic excellence, unscientific urban planning and ever-increasing automated transport (Bar et al. 1998). The differences in prevalence and trends of overweight and obese preadolescent children could be due to these influences. Lifestyle changes and an active policy to develop awareness among people regarding these influences could probably be a mode to combat these backgrounds.

IV. Conclusion

In this study we focused on several anthropometric, physiological and motor quality variables of preadolescent children from an urban area and found some of the children were overweight and obese. Statistical analysis of the variables reveals that there is increasing uncomfortable situation due to weight gain comparing with normal children. Disease causing factors are present in high percentage in those children with overweight and obesity comparing with children who were neither overweight nor obese. Unless effective interventions and preventive strategies are instituted at the local and national level, the trend of increasing cardiovascular and other disease in adults observed in recent decades will accelerate even further.

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PREVALENCE OF OBESITY AND CO-RELATIONSHIP OF SELECTED MOTOR QUALITY VARIABLES WITH BODY MASS INDEX AND FAT PERCENTAGE IN 5 TO 12 YEARS OLD SCHOOL GOING INDIAN BOYS

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ABSTRACT

This cross-sectional study was carried out in 1036 urban school going boys of 5 to 12 years of age from middle economic class Bengali families by race. For this study, different anthropometric and motor quality variables (including BMI, body fat%, hand reaction time, foot reaction time, speed of movement, agility, 30 meter sprint, standing long Jump test, vertical jump test) were measured in all selected boys. The result indicates the prevalence of being overweight and obese were 26.83% and 17.76% respectively of selected subject. BMI and motor quality values were significantly high in obese boys when compared with their non obese counterpart according to their chronological age. Product moment correlation coefficient analysis revealed that BMI and body fat percentage were significantly correlated (< 0.01) with the selected motor quality variable but BMI had not any significant correlation with speed of movement. BMI and body fat percentage were remarkably high in overweight and obese boys. Higher level of BMI and body fat percentage has a negative effect on motor performance skill. The information obtained from this study can therefore be used in the set of intervention programmes for school children in 5-12 years of age.

Keywords: BMI, Body fat%, Motor quality variable, Obesity, Overweight.

No. of Tables: 4 **No. of References: 54**

INTRODUCTION

The term obesity is defined as accumulation of excess fat in the body which has adverse effects on health. Different factors contributing to the development of childhood obesity are increased intake of high-calorie rich foods with little quantity of vitamins, micronutrients, mineral and less physical activity (Kaushik *et al.*, 2011). Video games, internet, television watching are the main underlying reasons of the physical inactivity for most children in developed and developing countries. The children in developing countries like India suffering from double form of malnutrition. Urban and semi-urban children's are afflicted with troubles of over-nutrition while rural and slam children suffer from under nutrition (Chatterjee, 2002). The several studies done in different parts of the India from 2007-2012 designate an increasing trend in the prevalence of overweight and obesity in children and adolescents (Sharma *et al.*, 2007; Kotian *et al.*, 2010; Khadilkar *et al.*, 2011; Chakraborty *et al.*, 2012).

Stature, body mass index, various skinfold thicknesses and other body dimensional measurements have internationally been established as perceptive indicators of growth and health status of children (Chatterjee and Mandal, 1993). The worldwide acceptable definition of obesity, BMI and stature are most easily assessable parameters for categorizing children as obese in age-gender-specific pattern (Cole *et al.*, 2002). Children with BMI ≥ 95th percentile are obese and those with BMI ≥ 85th percentile but < 95th percentile are defined overweight and are threat for obesity associated co-morbidities (Donohoue *et al.*, 2004).

Childhood obesity is related with a number of risk factors for the development of coronary heart disease and chronic problems such as hyperlipidemia, abnormal glucose tolerance, hypertension, orthopaedic problems, obstructive sleep apnoea, asthma, psychosocial problems, certain forms of cancer etc (Li *et al.*, 2004; Kuczmarski and Flegal, 2000). In addition to health problems, obesity is associated with poorer motor control, cognition and altered brain plasticity. Childhood obesity is also related to the reduced cognitive functions such as attention, executive function, mental rotation, reading achievement and mathematics (Davis and Cooper, 2011; Cserj´esi *et al.*, 2007; Jansen *et al.*, 2011; Lokken *et al.*, 2009; Lokken *et al.*, 2013). Obese children also have difficulty in postural coordination and increased dependency on vision to control locomotion which is quite automatic in normal weight children (D'Hondt *et al.*, 2011; D'Hondt *et al.*, 2008). Poorer posture and walking is associated with the excessive fat mass (Ponta *et al.*, 2014). Muscle quality ratio related with the adiposity that is associated with the peroneal nerve motor conduction velocity, memory performance and finger tapping speed (Moore *et al.*, 2014). Subcutaneous fatness can account for a significant variance of health-related and motor fitness (Malina *et al.*, 1995). The connection of childhood obesity to adulthood diseases is of major concern (Chatterjee *et al.*, 2006) since it is harder to treat obesity in adults than in children (Park and Park, 2005). So, to prevent of adult diseases due to obesity will require the prevention and management of childhood obesity (WHO, 2000).

Above mentioned health risk associated conditions are possibly related with the physical health profile of overweight and obese children. These health risk factors are associated with overweight and obesity in children which resists physiological action. It is important to determine the basic nature of the relationship between the physical fitness in terms of motor quality development and overweight and obesity in Indian Bengali boys.Hence, the main aim of this study was to determine the rate of prevalence of obesity and its effect on selected motor quality variables and its co-relationship with body mass index and fat percentage.

Material and Method

Selection of Subjects and Experimental Design

This cross- sectional study was conducted in different urban private schools of West Bengal in India during the period of 2010 to 2012. In this present study, initially total 1450 boys having age group between 5-12 years were included from middle socioeconomic class Bengali families which were considered in accordance with the guidelines laid down by ICMR (Agarwal, 2008). Among 1450 boys, 267 boys do not agreed to participate for volunteered study. Hence, 1183 boys were investigated for the present study. On the basis of BMI-age-percentile values (de Onis *et al.*, 2007), the boys those belong to underweight (147) were also excluded. Finally, 1036 boys were selected and data obtained from them in connection with the study. The boys were divided according to their chronological age into four groups such as 5-6 years, 7-8 years, 9-10 years, 11-12 (but below 13 years) years and also categorised in three sub divisions according to their BMI - age- percentile value such as normal weight, overweight and obese boys.

The age of the each boys were determined from their date of birth as recorded in their school register. The boys were randomly sampled from their population from different private sector school of three different districts such as Paschim Medinipur, Bankura & Purba Medinipur from West Bengal. For this study, the parents of the participating boys and also head of the school were asked to give written approval for their boys to be involved in this research programme .This study was done after the receiving of clearance from Human Ethical Committee from Vidyasagar University, Midnapore, West Bengal.

Measurement of anthropometric parameters

Height

Body stature was measured by adopting standard procedure (Johnson and Nelson, 1974). Body height was measured by the calibrated anthropometric rod procedure from reliable company. The stood bare foot and erect with heels together and arms hanging naturally by the sides. The height was recorded to the nearest centimetre.

Body mass

Body mass was measured by adopting standard procedure (Johnson and Nelson, 1974). Body weight of the subject was taken by the calibrated electronic portable weighing machine. The boys wearing vest and shorts stood at the centre of the weighing machine looking straight. The body weight was recorded to the nearest kilogram.

Body mass index (BMI)

BMI was calculated as the body weight in kilogram divided by height in square meters (kg.m^{-2}) .For the purpose of identification of overweight and obesity of the boys was considered by plotting BMI value on the WHO growth table to determined the corresponding BMI-for – age percentiles (de Onis *et al.,* 2007) and also following the proposed guidelines by T.J. Cole (Cole *et al.,* 2002).

Measurement of skinfold thickness

The skinfold thickness were measured at the right side on the triceps and sub-scapula with the boys standing in the proper erect posture according to the methods proposed by Johnson & Nelson (Jonson and Nelson, 1996) using Holtain skinfold callipers. For the computation of body fat% of boys were done using triceps and subscapular equation that is developed by Slaughter (Slaughter *et al.,* 1988).The equation is as follows:

Body fat % for boys = 783*(triceps + subscapular) -1.7

Measurement of motor performance variables

Determination of hand reaction time

The boys sited with his fore forearm and hand was resting comfortably on the table. The tips of the thumb and index finger were held in a ready to pinch position about 3 or 4 inches beyond the edges of the table. The upper edges of the thumb and index finger were in a horizontal position. Tester holds the stick timer close to the top, letting it hand between the boy's thumbs and index finger. The boys were directed to look at the concentration zone and were told to react by catching the stick when it is released. The boys were not allowed looking at the tester's hand and nor to move his hand up or down while attempting to catch the falling stick. The boys were allowed ten trials. Each drop was proceeded command of "ready". This procedure was followed by according methods proposed by Johnson & Nelson (Johnson and Nelson, 2007).

Determination foot reaction time

The boys were sited on a table which was about 1 inch from the wall. With his shoe off, the boys positions his foot so that the ball of the foot was held about 1 inch from the wall with the heel resting on the table about 2 inches from the edges. The tester holds the reaction timer next to the wall so that it hangs between the wall and the boy's foot with the base line opposite the end of the big toe. The boys look at the concentration zone and were told to react, when the timer was dropped, by pressing the stick against the wall with the ball of this foot. The boys were allowed ten trials (Johnson and Nelson, 2007).

Determination of speed of movement

The boys were sited at a table with his hands resting on the edges of the table. The palms were facing one another with the inside border of the little fingers along two lines which were marked on the edges of the cable 12 inches apart. The tester holds the timer near its top so that it hangs midway between the boy's palms. The base line was positioned so it is level with the upper borders of the boy's hands. After the introductory command "ready" was given, the timer (ruler) was released and the boys clapping the hands together. The boys must be careful not to allow his hands to move up or down when he was clapping the hands together. Ten trials were given (Johnson and Nelson, 2007).

30 meter sprint

The boys were instructed to perform 30 meter sprint (flying start) and the reading were taken in seconds by stop watch. For the measurement, the time was performed twice. From there, faster time was selected for analysis (Svensson and Drust, 2005).

Agility (4 × 10 meter shuttle run)

This test helps to know about the integral evaluation of the speed, agility and coordination. The subject does four shuttle runs as fast as possible between 2 lines 10 meters apart. At each end the boys places or picks up an item (a wooden block) beside the line on the floor (España-Romero *et al.,* 2010).

Vertical jump test

This test helps to know about the muscular strength. The subject was asked to stand erect facing the wall. His dominant hand's fingertips are to a maximum height on the wall without lifting the heels so as to mark his maximum reach point. The fingertips were chalked. With the chalked hand side towards the wall, a vertical jump was to be performed by the subject to make another mark at the maximum height of the jump. The subject was not allowed to run or hop. The subject was given two trials and from there, the best one performance was considered (Johnson and Bahamonde, 1996).

Standing long jump

This test is also called the Broad Jump. It is very common test for the measurement of the explosive power of the legs. The subject was to be stands behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Two trials were allowed, best one attempt was considered (Chung *et al.,* 2013).

Statistical Analysis

All the values of Anthropometric and Motor quality variable were expressed as Mean±SD (standard deviation). Analysis of variance (ANOVA) followed by Scheffe's multiple comparison test was performed to find out the mean difference of different Anthropometric and Motor quality variable of different categorised. In each cases significant level were chosen at 0.05 levels. Pearson product moment correlation coefficient (r) was used to examine the co-relationship of BMI and Fat percentage with the motor quality variable. Data analysis was executing using a statistical software package Origin 8.1 & Prism Graph pad 6.

Results

Prevalence of underweight, normal, overweight and obesity according to age groups (BMI Percentile)

In Table 1, it was showed that normal, overweight and obese boys were found 57.95%, 24.89%, 17.14% respectively in the age group 5-6 years. On the other hand, 55.93 %, 27.58% and 16.47% boys were found as normal, overweight and obese respectively from the age group 7-8 years. Prevalence of normal, overweight and obesity were found 55.89%, 23.95% and 20.95% respectively in 9-10 years age group. In case of 11-12 years age group, 52.05%, 30.71% & 17.22% boys were found as normal, overweight and obese respectively.

Table 1. Prevalence of normal weight, overweight and obesity according to age groups (BMI Percentile).

Age (Years)	No. of Sample	Frequency & Percentage	Normal	Overweight	Obese
5-6	245	F	142	61	42
		%	57.95	24.89	17.14
7-8	261	F	146	72	43
		%	55.93	27.58	16.47
9-10	263	F	147	63	53
		%	55.89	23.95	20.95
11-12	267	F	139	82	46
		%	52.05	30.71	17.22
Total	1036	F	574	278	184
		%	55.40	26.83	17.76

Comparison of different anthropometric variables of normal, overweight and obese boys

Present study showed that there was no significant variation of height of same age group among normal, overweight and obese (Table 2). On the other hand, when we compared with mean value of body mass, BMI and skinfold thickness, it was found that triceps, subscapula of normal boys of similar age group were significantly ($p<0.05$) differences with the overweight and obese boys. It was also observed that mean values of above mentioned parameters of overweight boys differed significantly ($p<0.05$) from those of obese boys of similar age group. Obese boys were found to possesses significantly higher values ($p<0.05$) of body fat% and LBM when compared with their non-obese counterpart of identical age group.

Table 2. Comparison of different Anthropometric variables of Normal weight, Overweight and Obese boys

Age (yrs.)	Category	Height (cm)	Body Mass (Kg)	BMI (Kg/m^2)	Body Fat%
5-6 (N=245)	Normal(a) (n=146)	113.2 ± 4.14	19.00 ± 1.82	14.86 ± 0.54	12.24 ± 1.84
	Overweight(b) (n=61)	113.51±3.62	22.53±1.81	17.51±0.49	18.16 ± 2.57
	Obese(c) (n=42)	114.15±3.65	26.51±1.83	20.40±0.89	21.71 ± 3.60
F values		0.77	296.59	1534.50	304.05
Level of significance		ns	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)

7-8 (N=261)	Normal(a) (n=146)	126.00±2.91	24.83±1.65	15.67 ± 0.71	13.40 ± 1.89
	Overweight(b) (n=72)	125.58±2.87	29.47±2.22	18.69 ± 0.71	20.09 ± 1.93
	Obese(c) (n=43)	125.87±2.77	33.97 ± 2.21	21.41 ± 0.70	24.57 ± 4.32
F values		0.49	403.59	1228.70	413.80
Level of significance		ns	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)
9-10 (N=263)	Normal (n=147)	135.73±2.98	29.5 ± 2.38	16.18 ± 0.94	13.15 ± 2.36
	Overweight (n=63)	136.85±2.86	37.29 ± 2.51	19.86 ± 0.79	21.65 ± 1.79
	Obese (n=53)	136.51±2.98	44.04 ± 3.98	23.59 ± 1.10	26.46 ± 3.54
F values		3.65	541.36	1271.81	629.52
Level of significance		ns	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)
11-12 (N=267)	Normal (n=139)	147.65±3.35	35.56±2.61	16.34 ± 0.84	14.13 ± 2.48
	Overweight (n=82)	147.39±3.23	47.63±3.40	21.94 ± 0.75	24.97 ± 2.09
	Obese (n=46)	147.47±3.12	53.88±4.22	24.78 ± 0.90	28.28 ± 4.21
F values		0.18	727.53	2314.42	655.62
Level of significance		ns	**(ab)(bc)(ac)	**(ab)(bc)(ac)	**(ab)(bc)(ac)

Values were expressed in terms of mean±SD, N; 1036, small 'n' indicates that number of samples in each category, one way ANOVA followed by Scheffe's multiple comparison test was performed among the group a, b and c for each parameter in each age group. (ab) indicates 'a' significantly differed from 'b' p<0.05, (bc) indicates 'b' significantly differed from 'c' p<0.05, (ac) indicates 'a' significantly differed from 'c' p<0.05; *indicates significantly differed of the values at the level of 0.05, **indicates significantly differed of the values at the level of 0.01, ns; not significant, BMI; body mass index

Comparison of different motor quality variables of normal, overweight and obese boys

In Table 3, Motor quality variables showed significant differences among normal, overweight and obese boys of similar age division. In case of 5-6 years age group, it was observed that obese boys had significantly ($p<0.05$) higher values of hand reaction time, foot reaction time, speed of movement, agility and 30 meter sprint than the normal weight and overweight boys. In case of vertical long jump test, there was a significant ($p<0.05$) variation observed between obese and overweight boys and as well obese and normal weight boys of 5-6 years age group. On the other hand, obese boys also exhibited significantly ($p<0.05$) higher values of hand reaction time, foot reaction time, speed of movement, agility and 30 meter sprint than the normal weight and overweight boys of 7-8 years age group. Alternatively, overweight boys also exhibited significantly ($p<0.05$) higher values of hand reaction time, foot reaction time, speed of movement, agility and 30 meter sprint than the normal weight boys of 7-8 years age group. The results obtained from the standing long jump, vertical jump test, hand reaction time, foot reaction time, speed of movement, agility and 30 meter sprint showed that significant differences ($p<0.05$) were found between the obese and overweight boys of 9-10 years age group. Alternatively, obese boys also exhibited significantly ($p<0.05$) higher values of hand reaction time, foot reaction time, speed of movement, agility and 30 meter sprint than normal weight boys of 9-10 years age group. In case of 11-12 years age group, the hand reaction time values showed that there was no significant difference between overweight and normal children.

Table 3. Comparison of different Motor quality variables among normal weight, overweight and obese boys

Age group (yrs.)	Category	HRT (sec)	FRT (sec)	SOM (sec)	Agility (sec)	30 meter Sprint(sec)	VJT (cm)	STLJ (cm)
5-6 (N=245)	Normal (a) (n=142)	0.279 ± 0.035	0.360 ± 0.013	0.812 ± 0.012	15.08 ± 0.670	7.76 ± 0.234	20.25 ± 3.53	97.3 ± 9.73
	Overweight (b) (n=61)	0.320 ± 0.049	0.394 ± 0.016	0.831 ± 0.009	16.60 ± 0.538	8.00 ± 0.248	16.09 ± 2.96	88.13 ± 11.30
	Obese (c) (n=42)	0.346 ± 0.048	0.408 ± 0.020	0.859 ± 0.027	18.41 ± 0.532	8.80 ± 0.352	12.79 ± 2.76	74.08 ± 6.78
F values		49.93	210.04	157.25	544.89	253.22	96.53	95.83
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)
7-8 (N=261)	Normal (a) (n=146)	0.258 ± 0.034	0.334 ± 0.013	0.786 ± 0.020	14.10 ± 0.609	6.80 ± 0.300	26.23 ± 4.20	110.38 ± 12.07
	Overweight (b) (n=72)	0.299 ± 0.050	0.364 ± 0.022	0.814 ± 0.019	15.54 ± 0.615	7.25 ± 0.308	21.04 ± 3.71	103.52 ± 11.39
	Obese (c) (n=43)	0.319 ± 0.040	0.384 ± 0.024	0.839 ± 0.015	16.71 ± 0.565	8.20 ± 0.216	17.23 ± 3.02	93.64 ± 13.33
F values		48.60	148.59	142.25	361.07	393.46	105.25	33.39
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)
9-10 (N=26)	Normal (a) (n=147)	0.235 ± 0.037	0.294 ± 0.019	0.734 ± 0.019	13.30 ± 0.558	6.32 ± 0.209	31.74 ± 5.07	123.69 ± 12.95
	Overweight (b) (n=63)	0.266 ± 0.046	0.329 ± 0.014	0.761 ± 0.014	14.73 ± 0.294	6.60 ± 0.240	24.85 ± 4.57	112.92 ± 11.69
	Obese(c) (n=53)	0.296 ± 0.039	0.346 ± 0.018	0.782 ± 0.018	15.80 ± 0.328	7.50 ± 0.306	20.76 ± 3.75	103.13 ± 11.76
F values		48.78	180.48	69.33	625.85	475.30	122.36	56.64
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)
11-12 (N=267)	Normal (a) (n=139)	0.223 ± 0.041	0.273 ± 0.024	0.630 ± 0.028	12.63 ± 0.404	5.77 ± 0.336	35.71 ± 5.42	145.30 ± 19.75
	Overweight(b) (n=82)	0.244 ± 0.049	0.304 ± 0.020	0.664 ± 0.042	14.15 ± 0.461	6.20 ± 0.361	29.38 ± 4.01	130.27 ± 10.27
	Obese(c) (n=46)	0.269 ± 0.063	0.318 ± 0.030	0.684 ± 0.038	15.10 ± 0.240	7.42 ± 0.393	25.93 ± 4.27	119.11 ± 8.96
F values		16.34	77.12	50.26	791.06	373.49	88.93	55.61
Level of significance		*(ab)(bc)(ca)	*(ab)(bc)(ca)	*(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)	**(ab)(bc)(ca)

Values were expressed in terms of mean±SD. N; 1036, small 'n' indicates that number of sample each category, one way ANOVA followed by Scheffe's multiple comparison test was performed among the group a, b and c. (ab) indicates 'a' significantly differed from 'b' $p<0.05$, (bc) indicates 'b' significantly differ from 'c' $p<0.05$, (ac) indicates 'a' significantly differ from 'c' $p<0.05$, *indicates significantly differed of the values at the level of 0.05, **indicates significantly differed of the values at the level of 0.01, ns; not significant, HRT; hand reaction time, FRT; foot reaction time, SOM; speed of movement, 30MS; 30 meter sprint, SLJT; standing long jump test, VJT; vertical jump test.

Analysis of correlation of fat % and BMI with different motor quality variables

The relationship of body fat% and BMI with different motor quality variables are shown in Table 4. BMI was found to have significant positive correlation with different motor quality variables such as hand reaction time (r = +0 .417; 95% CI 0.42, 0.52; P < 0.01), foot reaction time (r

= +0.411; 95% CI 0.35, 0.46; P < 0.01), agility (r = +0.364; 95% CI 0.31, 0.41; P < 0.01) but significantly negative correlation was found with the vertical jump test (r = - 0.166; 95% CI - 0.22, - 0.10; < 0.01). On the other hand, body fat% was found to have significant positive correlation with the selected motor quality variables like hand reaction time (r = 0.614; 95% CI 0.57, 0.65; P < 0.01), foot reaction time (r =0.510; 95% CI 0.46, 0.55; P< 0.01), speed of movement (r = 0.082; 95% CI – 0.21, 0.14; p = 0.082), agility (r = 0.413; 95% CI 0.36, 0.46; P< 0.01), 30 meter sprint (r = 0.276; 95% CI 0.21, 0.36; P< 0.01) and negatively correlated with the gross motor skill such as standing long jump test (r = - 0.162; 95% CI - 0.22, - 0.10; P< 0.01), vertical jump test (r = - 0.209; 95% CI - 0.26, -0.15; P< 0.01).

Table 4. Product moment correlation coefficient of BMI and Percentage of Body fat with different Motor quality variables (no. of cases 1036)

Variables	BMI (kg/m^2)			Body fat%		
	r values	95% CI	Significance (p)	r values	95% CI	Significance (p)
HRT (sec)	0.286	0.229, 0.341	< 0.01	0.396	0.342, 0.448	< 0.01
FRT (sec)	0.136	0.076, 0.195	< 0.01	0.247	0.188, 0.303	< 0.01
SOM (sec)	-0.055	-0.11,-0.00	ns	0.016	- 0.044, 0.07	ns
Agility (sec)	0.365	0.311, 0.416	< 0.01	0.398	0.340, 0.443	< 0.01
30 meter sprint (sec)	0.179	0.120, 0.238	< 0.01	0.218	0.160, 0.276	< 0.01
VJT (cm)	- 0.167	- 0.225, - 0.107	< 0.01	- 0.217	- 0.274, - 0.158	< 0.01
SLJT (cm)	- 0.091	- 0.129, - 0.008	<0.05	- 0.145	- 0.204, - 0.084	< 0.01

Two tailed of significance was used, ns; not significance, 95% CI; 95% Confidence intervals.

DISCUSSION

It is well established from different worldwide obesity related studies (Ortega and Ruiz, 2007; Bovet and Burdette, 2007) that overweight and obesity are global epidemic and threat in children and also in pubescent. From the present study, the prevalence of being overweight and obesity in the selected boys were (5-12 years of age) 26.83% and 17.76% respectively. On the other hand, 55.40% boys were normal weight out of 1036 selected sample. From the results, it has also been noted that the prevalence of overweight (30.71%) and obesity (17.92%) was high in 11-12 and 9-10 years of age group respectively. Similar trend of prevalence rate of overweight and obesity was also reported previously at Pune city in India. (Khadilkar and Khadilkar, 2004; Mahshid *et al.*, 2005).

In our study it has been shown that the obese boys were not able to run quickly as their non-obese counter part of identical age group, similar results were found from the study of Graf *et al.*, (2004) and Morano *et al.*, (2011). On the other hand, gross motor skill like jumping ability in the form of standing long jump, vertical long jump value of obese boys were very poor when compared with non-obese group in the same group in our study.

D'Hondt *et al.*, (2007) reported that children with high BMI and fat % affect the fine and gross motor skill performance under different postural constraints. Deposition of excess fat on the limb joint reduces the limb movement and decreases reflex also. It was found that obesity influences the body geometry and increases the mass of different body segments (Mukherjee *et al.*, 2015). A report also revealed that children who were obese and overweight showed much more impairments in motor proficiency and were less physically active when compared with the non-obese counterpart (Numez-Gaunaurd *et al.*, 2013).

According to other studies showed that the overweight and obese children were significantly weaker from normal weight children in standing long-jump as well as in vertical jump performance as measurements of muscle strength (Tokmakidis *et al.*, 2006; Wearing *et al.*, 2007). Our study have also shown that the mean values of vertical jump and standing long jump were significant (p<0.05) higher in 11 to 12 years old boys in three body weight categorise because this age group represents the onset of adolescence. In the onset of puberty or during puberty, children obtain the capability to take higher advantages of elastic energy storage in the musculotendinous system while performing peak counter-movement jumps (Korff *et al.*, 2009).

A study also indicated that overweight and obese boys as well as girls in the 6-18 year old age group were found significantly weaker in abdominal muscle patience tests (Chen *et al.*, 2006). In addition, we also observed a significant (p<0.01) inverse relationship of BMI and fat % with fine motor skill like hand reaction time, foot reaction time and speed of movement. Similar results also found in few previously studies in children with different ages ranging from kindergarten to 10 years (Kambas *et al.*, 2012; Morrison *et al.*, 2012).

Although, few studies (Eckner *et al.*, 2006) has reported positive relationship between reaction time and obesity, but the results of present study demonstrated significantly (p <0.01) positive correlation between body fat % and motor performance skill that means higher body fat values in boys indicated lower motor performance skill in terms of reaction time.

The results of present study also demonstrated that motor quality (in terms of agility, 30 meter sprint) values were lower in obese children than in normal weight and overweight boys in all age group. Therefore, obese subjects are not enable rapidly change their body position and direction in precise manner. Generally, there are consistent inverse correlations among weight status and motor competence (Jones *et al.*, 2010; Barnett *et al.*, 2008).

The mean values of vertical jump and standing long jump were the lowest in overweight and obese boys when compared with healthy normal weight boys, the reason for poorer performances may be the difficulty faced during moving extra load generated from excess body fat during weight bearing task (Chen *et al.*, 2002; Malina *et al.*, 1995).

It is understandable from the results of the study that overweight and obesity do have a negative effect on the health promotional motor quality fitness variable of 5 to 12 years school children. The negative effect is the greatest in muscle power, speed, flexibility and fine motor skill of overweight and obese boys.

Conclusion

From this study it can be concluded that BMI and fat % are remarkably high due to higher level of body fat in overweight and obese boys. Higher level of BMI and body fat % has a negative effect on motor performance skill. The information obtained from this study can therefore be used in the set of intervention programmes for school children in 5-12 years of age. Furthermore, it provides confirmation for the essential of a strong establishment of motor quality development in relation to a physically active lifestyle for all boys. This study have been inadequate by its cross-sectional intend. Future studies required to employing a longitudinal design for completely recognize the composite relations of obesity and motor quality development in 5 to 12 years boys.

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Research Article (Open access)

Associations of Obesity Indices with Cardiorespiratory Fitness in Bengali School Going Boys in India

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ABSTRACT- This study determined the relationship between obesity parameters (Body Mass Index, Waist Hip Ratio, Waist Thigh Ratio and Body Fat Percentage) and cardio respiratory fitness in terms of physical fitness index (PFI) and also were compared the selected physiological parameters (resting pulse rate, respiratory rate and blood pressure) among three body weight categories of selected boys. The present study was carried out in 233 healthy school going Bengali boys aged 11 to <13 years from India. On the basis of BMI-age-boys Z-scores, boys were categorised in three subdivisions such Normal weight, Overweight and Obese. The Scheffe's multiple comparison post hoc analyses showed ($p<0.05$) significant difference of selected physiological parameters in each pairs of categories. The lowest (5th) to highest (95th) percentiles values of PFI were higher in normal weight categories than those in over weight and obese categories. Anthropometric obesity parameters were found to have significant ($p < 0.001$) and negative correlation with physical fitness index (PFI). However, multiple regression analysis found that only body mass index and waist hip circumference (WHR) were independently and significantly associated with the physical fitness index (PFI). The present study reveals that higher values of BMI, body fat% and WHR may be responsible for lower score of PFI which indicates low cardiorespiratory fitness in Bengali overweight and obese children.

Key-words- Obesity, BMI, WHR, PFI, Cardiorespiratory fitness, Boys

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INTRODUCTION

Physical fitness index (PFI) is considered as an important and valuable parameter in the field of sports and exercise physiology and is very important aspect for an individual life. Body mass index (BMI), body fat% and waist to hip ratio (WHR) are useful tools for determining obesity. Health related physical fitness of children is dependent on lifestyle related factors such as daily physical activity levels.

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It was believed that the low physical fitness level of an individual is associated with higher mortality rate [1]. Determination of Physical Fitness Index (PFI) is one of the important criteria to assess the cardiopulmonary efficiency of a subject. Physical fitness level of an individual depends on the amount of oxygen which can be transported by the body to working muscles, and the efficiency of muscles to use that oxygen [2]. Distribution of fat centrally, with increases waist circumference thought to reflect increases in visceral fat with age [3]. The relationship between obesity indices and physical fitness index are well documented in other populations by several previous studies [4-6] which show the importance of physical fitness index in obesity management in children. Another study on the subjects of Kolkata of West Bengal in India documented similar findings [7]. BMI, body fat% and waist to hip ratio, waist to thigh ratio have been used to evaluate health risks associated with overweight and obesity. The objectives of this study were to evaluate the relationship of PFI score with different anthropometric obesity parameters (i.e., BMI, body fat%, WHR and WTR) and comparison of PFI score among three body weight categories of boys aged 11 to < 13years in West Bengal.

MATERIALS AND METHODS

The present study was carried-out in 233 healthy school going Bengali boys aged 11 to <13years. The subjects were drawn by simple random sampling from different urban private schools of mainly three districts (Bankura, Paschim Medinipur and Purba Medinipur) of West Bengal in India. On the basis of BMI- age-boys Z-scores (normal weight: -2SD > BMI Z score < + 1SD, overweight: BMI Z-score ≤ +2SD, obese: BMI Z-score > +2SD), boys were categorised in three subdivisions such Normal weight, Overweight and Obese [8]. The age of the boys were determined from their date of birth as recorded in their school registered. Ethical approval and prior permission were obtained from the Institutional Ethical Committee before commencement of the study and the experiment was performed in accordance with the ethical standard of the committee. For this study, the parents of the participating boys and also head school were asked to give written approval for their boys to be involved in this research programme.

Measurement of obesity parameters

Body mass index (kg.m^{-2})

Body mass index (BMI) was calculated as the body weight in kilogram divided by height in square meters (kg.m^{-2}). For the purpose of identification of overweight and obesity of the boys the cut off values of BMI set by the World Health Organization [8] was used.

Measurement of circumferences (cm)

All the selected circumferences in the present study were measured according to the recommendation of WHO [9]. Waist circumference was measured midway between the lower rib margin and the iliac crest. Hip circumference was measured horizontally at the level of gluteal muscle (at maximum circumference). Thigh circumference was measured as the horizontal girth at the level of the gluteal fold on the right thigh.

Computation of Body fat percentage

The skinfold thickness were measured at the right side on the triceps and subscapula with the boys standing in the proper erect posture according to the methods proposed by Johnson & Nelson [10], using Holtain skinfold callipers. For the computation of body fat% of boys were done using triceps and subscapular equation that is developed by Slaughter et al. [11].The equation is as follows:

Body Fat % for boys = 783*(Triceps + Subscapular) - 1.7

Determination of physiological parameters

Blood pressure was determined using a mercury sphygmomanometer as per the recommendations of American Heart Association [12]. The measurements were taken in a quiet room in the sitting posture with the arm resting on the table. The average of three consecutive readings was taken as the blood pressure of the child. Resting heart rate was measured after a complete rest of 3 minutes by taking the radial pulse. Three successive readings were taken in the resting state for 60 seconds each with an interval of one minute while the person was sitting. Resting respiratory rate was determined by the method mentioned by the William et al. [13].

Physical fitness index (PFI)

PFI was determined by Modified Harvard Step Test (HST – III). This test was done according to the method developed by Brouha & Ball [14], applicable to elimentary school children. The method is as follows:
Every boy studied was advised to step up on the modified Harvard steps on 14 inches height (bench) once in every two seconds (i.e. 30 times per minute) for 3 minutes, a total of 90 steps. Post exercise recovery pulse was recorded as:

a) **Pulse rate 1** – 2 minutes after exercise
b) **Pulse rate 2** – 3 minutes after exercise
c) **Pulse rate 3** – 4 minutes after exercise

$$\text{PFI} = \frac{\text{Duration of exercise in seconds}}{2\times(\text{Recovery pulse rate } 1^{st} + 2^{nd} + 3^{rd} \text{ Minutes})} \times 100$$

STATISTICAL ANALYSIS

All the values of anthropometric and physiological variables were expressed as Mean ± SD (standard deviation). Analysis of variance (ANOVA) followed by Scheffe's multiple comparisons test was performed to find out the mean difference of different anthropometric and physiological variable of different categorised. In each cases significant level were chosen at 0.05 levels. Pearson product moment correlation coefficient (r) was used to examine the co-relationship of anthropometric obesity indices with the physical fitness index. Multiple regressions were used to study the association of anthropometric obesity marker (ie, BMI, body fat percentage, WHR and WTR) with physical fitness index (PFI). The analyses were performed using the Statistical Package for Social Sciences (SPSS, version 20.0; SPSS Inc., Chicago, Illinois, USA), and the level of significance was set to $p<0.05$.

RESULTS AND DISCUSSION

Comparison of selected anthropometric obesity parameters among three body weight categories

Comparison of selected anthropometric obesity parameters among three body weight categories of boys are presented in Table 1. One way ANOVA was performed to make an overall comparison of the selected anthropometric obesity parameters among three body weight categories. Further, Scheffe's multiple comparison tests were performed to identify significant difference in each pair of categories. It is observed from Table 1that there existed no significant difference in height among three body weight categories. On the other hand, weight, BMI, WHR, and body fat% differed significantly ($p<0.001$) among three body weight categories. Moreover, in post hoc multiple comparison tests all pairs of body weight categories showed significant difference ($p<0.01$) among three body weight categories.

Table 1. Comparison of selected anthropometric obesity parameters among three body weight categories of boys (Normal weight boys = 125, Overweight boys = 68, Obese boys = 40)

Categories	Height (cm)	Weight (kg.)	BMI (kg.m^{-2})	WHR	WTR	Body fat%
Normal weight (a)	147.34 ± 3.31	36.08 ± 2.75	16.59 ± 0.79	0.858 ± 0.026	1.549 ± 0.080	14.13 ± 2.48
Overweight (b)	146.85 ± 3.23	46 .93 ±3.57	21.72 ± 0.90	0.955 ± 0.024	1.647 ± 0.059	21.83 ± 0.87
obese (c)	147.01 ± 3.01	53.69 ± 5.59	24.78 ± 1.69	0.980 ± 0.022	1.753 ± 0.063	24.97 ± 1.66
Level of significance	ns	***(ab)(ac)(bc)	***(ab)(ac)(bc)	***(ab)(ac)(bc)	** (ab)(ac)(bc)	***(ab)(ac)(bc)
F values	0.18	437.58	1177.29	528.13	151.57	696.34

Note: Values are Mean ± SD

*One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected anthropometric obesity parameters among three body weight categories in 11 - < 13 years age group (** $p < 0.01$, *** $p < 0.001$, ns = not significant). Sceffe's multiple comparison tests were performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'. BMI = body mass index, WHR = waist to hip ratio, WTR = waist to thigh ratio.*

Comparison of selected physiological parameters among three body weight categories Comparison of selected physiological parameters of three body weight categories has been presented in Table 2. The results from the Table 2 showa significant variation ($p<0.01$) of PFI and SBP among three body weight categories. The Scheffe's multiple comparisons post hoc analysis showed ($p<0.05$) significant difference of selected physiological parameters in each pairs of categories. The mean values of SBP, DBP, pulse rate and respiratory rate significantly higher in obese boys than in normal weight boys. On the other hand, mean values of PFI significantly ($p<0.01$) higher in normal weight boys than in overweight and obese boys. Earlier, Indian studies have also found PFI score of normal weight boys to be higher than in over weight and obese boys [15].

Blood pressure and adiposity in children and adolescents were assessed by Paradis et al. [16], and showed that resting heart (RHT) rate was increased, which suggests some degree of increased sympathetic activity, body mass index (BMI) was consistently associated with increase in SBP and DBP in all age-gender groups. The mean resting pulse rate was significantly higher in obese boys than in normal weight and overweight categories due to activation of the sympathetic nervous system occurs early in the course of obesity and the autonomic nervous system is an important contributor to the regulation of both the cardiovascular system and energy expenditure [17-18].

On the other hand, the probable reason of high respiratory rate in obese boys due to the increased adiposity around ribs, diaphragm and abdomen leading to limited movement of ribs, decreased total thoracic and pulmonary volume causes reduction in chest wall compliance and preventing full excursion of the diaphragm [19-20].

Table 2. Comparison of selected physiological parameters among three body weight categories of boys (Normal weight boys = 125, Overweight boys = 68, Obese boys = 40)

Categories	PFI score	Resting SBP (mmHg)	Resting DBP (mmHg)	Resting pulse rate (bpm)	Resting respiratory rate (cpm)
Normal weight (a)	50.61 ± 8.06	104.02 ± 7.32	62.07 ± 7.18	86.68 ± 15.39	18.29 ± 3.46
Overweight (b)	40.58 ± 5.49	110.45 ± 6.64	66.30 ± 7.82	90.52 ± 15.41	19.01 ± 3.50
Obese (c)	36.87 ± 3.32	114.42 ± 9.24	72.45 ± 8.60	93.9 ± 14.58	20.35 ± 3.97
Level of significance	**(ab)(ac) (bc)	** (ab)(ac)(bc)	* (ab)(ac)(bc)	*(ac)	* (ab)(ac)(bc)
F values	86.01	37.14	29.25	3.83	5.84

Note: Values are Mean ± SD

One way ANOVA (expressed by F value and level of significance) was performed to show the overall differences of the selected physiological parameters among three body weight categories in 11 - < 13 years age group ($p < 0.05$, ** $p < 0.01$, ns = not significant). Sceffe's multiple comparison tests were performed in every pair of three body weight categories a, b and c, where (ab) indicates 'a' significantly ($p < 0.05$) differed from 'b', (ac) indicates 'a' significantly ($p < 0.05$) differed from 'c', (bc) indicates 'b' significantly ($p < 0.05$) differed from 'c'. SBP = systolic blood pressure, DBP = diastolic blood pressure, PFI = physical fitness index.*

Range of PFI score among three body weight categories

Table 3 shows that the mean PFI of normal weight categories was 50.61 (range 38.29 to 64.74). On the other hand, mean PFI of overweight categories was 40.58 (range 34 to 58.44). In contrary, mean PFI of obese categories was 36.87 (range 32.49 to 42.58).

Table 3. Mean, standard deviation (SD), median and range of PFI scores of three body weights categories

Categories	Parameter	Mean	SD	Median	Minimum	Maximum
Normal weight	PFI	50.61	8.06	50.27	38.29	64.74
Overweight		40.58	5.49	39.48	34.0	58.44
Obese		36.87	3.32	36.66	32.49	42.58

Comparison of percentile values of PFI score among three body weight categories

Comparison of 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles of PFI scores among three body weight categories are presented in Table 4. It is observed from the Table 4 that the 5th, 10th, 25th, 75th, 90th and 95th percentile values of PFI were higher in normal weight categories than in over weight and obese categories. In contrary, the lowest (5th) to highest (95th) percentiles values of PFI were higher in overweight categories than in obese categories.

Table 4. Comparison of selected percentiles values of PFI among three body weight categories

Categories	Mean	SD	Percentile						
			5th	10th	25th	50th	75th	90th	95th
Normal weight	50.61	8.06	40	40.54	42.85	50.27	55.90	62.5	63.38
Overweight	40.58	5.49	34.61	35.15	36.29	39.48	43.17	47.61	52.63
Obese	36.87	3.32	32.66	32.96	33.51	36.66	39.73	41.66	42.35

Determination of association BMI and body fat% with physical fitness index (PFI)

Pearson's product-moment correlation coefficients of BMI and body fat% with physical fitness index (PFI) were presented in Table 5. Correlation analysis showed that BMI had significant (p<0.001) and negative correlation with physical fitness index (PFI). In contrary, result also showed (Table 5) that body fat% had significant negative correlation (p<0.001) with physical fitness index (PFI). The findings of the present research confirmed the finding of these earlier studies in the present Bengali children where PFI was significantly and negatively correlated with BMI and body fat percentage [21-22]. The observed negative association between body fat percent and physical fitness index (PFI) score concur with previous studies where sophisticated techniques to measure body composition were used [23-26]. On the other hand, Gutin et al. [24] assessed body fat by dual energy x-ray absorptiometry (DXA) in youth and showed a negative association between body fat% and cardiorespiratory fitness in terms of PFI.

Table 5. Pearson's product moment correlation coefficient of BMI and % of Fat with PFI (No of cases: 233)

	BMI(kg/m^2)			Body fat%		
Variable	r values	95% CI	Level of signific-ance (p)	r values	95% CI	Level of significance (p)
PFI	- 0.632	- 0.704, - 0.548	< 0.001	- 0.599	- 0.675 , - 0.51	< 0.001

Note: 2-tailed of significance was used, ns = not significance, 95 % CI = 95% confidence intervals, BMI = body mass index, PFI = physical fitness index

Determination of association of WHR and body WTR with physical fitness index (PFI)

Pearson's product-moment correlation coefficients of WHR and WTR with physical fitness index (PFI) were presented in Table 6. Pearson's product-moment correlation coefficient analysis demonstrated that WHR had significant (p<0.001) and negative correlation with physical fitness index. On the other hand, result (Table 6) also showed that WTR had significant (p<0.001) and negative correlation with physical fitness index (PFI). Our present finding also corroborate with the findings of Ortega et al. [27-28], they observed that physical fitness index was negatively associated with waist circumference in Swedish and Spanish youth. On the other hand, Winsley et al. [23] showed that visceral obesity assessed by MRI was negatively associated with cardiorespiratory fitness in children.

Table 6. Pearson's product moment correlation coefficient of WHR and WTR with PFI (no of cases: 233)

	WHR			WTR		
Variable	r values	95% CI	Level of significance (p)	r values	95% CI	Level of significance (p)
PFI	- 0.621	- 0.694, - 0.535	< 0.001	- 0.411	- 0.512, - 0.298	< 0.001

Note: 2-tailed of significance was used, ns = not significance, 95 % CI = 95% confidence intervals, WHR = waist to hip ratio, WTR = waist to thigh ratio

Multiple linear regression analysis

Multiple linear regression analysis was performed to see whether there were independent relationships of anthropometric obesity parameters (i.e., BMI, body fat%, WHR and WTR) with PFI and standard partial regression coefficients (β) are presented in support of that (Table 7). Multiple regression analysis demonstrated that waist to hip ratio (WHR) had independent significant (p<0.001) negative impact on physical fitness index (PFI) when body mass index (BMI), body fat % and waist to thigh ratio were controlled.

Table 7. In multiple regression analysis PFI is dependent variable and BMI, body fat%, WHR and WTR are independent variables

Physical fitness index (PFI) is dependent variable										
Independent Variable	Constant (A)	Unstandarzied coefficient		Standardized coefficient	t	Level of significance (p)	F	Level of significance (p)	R^2
		B	Std. Error	Beta (β)					
BMI	98.85	-1.32	0.48	- 0.53	-2.79	p<0.006	43.96	p<0.001	0.43
Body fat%		0.09	0.23	0.13	0.75	ns			
WHR		-57.52	15.70	- 0.38	-3.66	p<0.001			
WTR		-13.25	6.30	0.15	-2.10	0.036			

Note: BMI = body mass index, WHR = waist hip ratio, WTR = waist to thigh ratio

Hence, it appears from the present study that waist to hip ratio (WHR) is partly good detector for variability of physical fitness index (PFI) in these children. Our findings well support with previous finding in Bengali children and adolescent by Mukherjee and Dhara [21]. It is also observed from the Table 7 that even after controlling the effects of body fat %, waist to hip ratio (WHR) and waist to thigh ratio (WTR), BMI had independent significant (p<0.006) and negative association with the physical fitness index (PFI) , this finding similar as the earlier finding of Das and Dhundasi [29]. Increased central adiposity may lower utilization of oxygen per unit of body mass or respiratory trouble may occur due to higher amount fat deposition in the abdomen and chest cavity. This may restrict proper functioning of heart especially during physical activities or exercises [30]. Thus on the basis of the present study it may be said that higher values of BMI, body fat percent and WHR may be responsible for lower score of PFI. Increased cardio respiratory fitness had been found to lower BMI, body fat% and WHR [30].In light of these earlier studies and results of the present study it may be said that obesity indices has a negative effect on cardio-respiratory fitness in terms of physical fitness index (PFI).

CONCLUSION

The mean value of physical fitness index (PFI) was found to be higher in normal weight boys than in overweight and obese boys. Resting heart rate, respiratory rate and blood pressure were higher in overweight and obese children compared to normal children. The findings documented herein found significant negative association of obesity parameters (i.e., BMI, Body Fat%, WHR and WTR) with PFI. This indicates a lower level of cardiovascular efficiency in overweight and obese boys compared to normal weight boys. The results of this study emphasizes the need for early identification of the risk factors leading to exces sive BMI, body fat% and initiation of preventive measures in order to prevent the deterioration of cardiovascular performance in 11 to <13 years old school going Bengali boys.

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