MULTIPLE CORRELATES OF OBESITY AMONG SCHOOL CHILDREN

Thesis submitted to Mahatma Gandhi University for the award of the degree of

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in HOME SCIENCE

(SCIENCE)

by

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FOOD AND NUTRITION

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DECLARATION

I hereby declare that the dissertation entitled '**MULTIPLE CORRELATES OF OBESITY AMONG SCHOOL CHILDREN**' submitted to Mahatma Gandhi University, Kottayam, in fulfillment of the requirement for the award of the degree of **Doctor of Philosophy in Home Science (Science)** is a record of original research work, done by me under the supervision and guidance of Prof. Dr. K.S. Kumari, M.Sc., Ph.D., Head of the Department of Home Science (Rtd.), St. Teresa's College Ernakulam, and it has not formed the basis for the award of any Degree/ Diploma/ Associateship/ Fellowship or similar title to any candidate of any other university.

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CERTIFICATE

This is to certify that the dissertation entitled '**MULTIPLE CORRELATES OF OBESITY AMONG SCHOOL CHILDREN**' submitted to Mahatma Gandhi University, Kottayam, in fulfillment of the requirement for the award of the degree of **Doctor of Philosophy in Home Science (Science)** is a record of original research work done by **Seeja Thomachan Panjikkaran** during the period of her study in the **Centre for Research in Home Science, St. Teresa's College, Ernakulam**, under my supervision and guidance. This dissertation has not formed the basis for the award of any Degree/ Diploma/ Associateship/ Fellowship or similar title to any candidate of any other University and it represents entirely an independent work on the part of the candidate.

Signature of the Guide
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I. INTRODUCTION

Childhood is the foundation of adulthood. Food habits, nutritional status and lifestyle in childhood are the major contributors that determine the health of an adult. Unhealthy diet and lack of physical activity during childhood are the leading risk factors accounting for the burden of non-communicable diseases in adulthood (Bharati *et al*., 2008).

India being a developing country, has an array of nutritional deficiency disorders of varying degrees among our child population especially school children in the age group of 7 to 12 years. School children account for more than a third of India's population, estimated at 1.2 billion in 2009. In the state of Kerala school going children are estimated to be 11 million; out of a total population of 33 million (Anonymous, 2010). India's future is in the hands of children and depends on their potential and contribution.

The developmental transition over the last few decades brought in lifestyle changes, which in turn have resulted in nutritional transition. As Raj *et al*., (2007) rightly pointed out India is going through a nutrition transition phase and is now facing the double burden of nutritional disorders. In India, obesity is emerging as important health problem particularly in urban areas, paradoxically co-existing with under nutrition (Misra *et al*., 2009). Under nutrition and infectious diseases, the most significant contributor to ill health, show marginal decline in their severity and replaced by obesity and related problems.

Obesity is a natural consequence of over-nutrition and sedentary lifestyle (Misra and Khurana, 2008). It is a state of excess macrophage accumulation in adipose tissue (Weisberg *et al*., 2003). The definition for excess body weight and obesity among children is based on the percentile values of body mass index adjusted for age and gender corresponding to BMI of 25 and 30 kg/m^2 (WHO, 2007).

Historically, a fat child is a healthy child, who is likely to survive the rigors of under nourishment and infection. But unlike the past, today obesity or overweight in childhood is considered as a major health risk condition developed mainly due to malnutrition and improper lifestyle and which can lead to a number of health problems both in childhood and later in adulthood (Remacle *et al*., 2004).

Childhood obesity is alarmingly increasing worldwide and it is linked with an increased risk of obesity in adulthood resulting in morbidity and mortality. Globally the annual rate of increase in the prevalence of childhood obesity has been growing steadily and the current rate is ten times higher than it was in the 1970s (WHO, 2007).

Obesity in children and adolescents is gradually becoming a major public health problem in many developing countries, including India (Popkin and Doak, 1998). School based data on prevalence of overweight and obesity in India demonstrates an obesity range of 5.6 to 24.0 per cent for the children and adolescents. The prevalence is higher in urban than in rural areas (Kaur *et al*., 2005; Kapil *et al*., 2002). Although a majority of children in Kerala are underweight, the state is fast catching up with the West in childhood obesity (Maya, 2007). Varghese and Vijayakumar (2008) have reported an overall prevalence of obesity and overweight at 5.5 and 24.8 per cent respectively in Kerala.

Multiple factors are responsible for the development of obesity. It is essential to identify the degree of major risk factors contributing to this menace. A large number of factors both proximal and distal to the individual have been identified as contributing to the increasing prevalence of overweight among children, including genetic, familial, dietetic, socioeconomic, psychosocial, behavioural, and environmental factors (Davison and Birch, 2001). Worldwide, the dietary intake is increasing and physical activity is reducing (Aaron *et al*., 2002; Kimm *et al*., 2000). India is a country with the largest population density and a major part of the population below the poverty line; hence the real prevalence of obesity and overweight should be closely monitored at grass-root level.

Considerably less information is available regarding determinants of overweight among Indian children. Hence it is the need of the hour to understand the nutritional status, prevalence and major contributories for obesity/ overweight/ underweight conditions and their interrelationships among Indian children, suitability of various cut-off points proposed for defining the childhood obesity and if found unsuitable, to define more precise cut-off points.

The identification of obesity and overweight in childhood as an important aspect of preventive paediatrics with implications for the promotion of physical, social and emotional health of children has also been pointed out by Paul (2004). The increased prevalence of paediatric obesity and its associated morbidities demonstrate the need for a simple anthropometric tool that can be used to assess and identify children who are at risk of becoming obese and subsequently require appropriate intervention.

Although a wide variety of definitions of child obesity are in use and no commonly accepted standards have yet emerged (Parsons *et al*., 1999). BMI centiles (Khadilkar *et al*., 2007; Cole *et al*., 2000; CDC, 2000) waist circumference centiles (McCarthy *et al*., 2001) and waist to height ratio (McCarthy and Ashwell, 2003) are some of the accepted standard measures to determine obesity among children. While using BMI, it is proposed by the International Obesity Task Force that the adult cut-off points need to be linked with body mass centiles for children to provide child cut-off points. However it has also been pointed out, that BMI may be a less sensitive indicator of obesity among children, since it gives no indication about fat distribution (McCarthy *et al*., 2001). This necessitates a methodology that considers all the growth dynamics and applicable to all ethnic groups for establishing standard obesity percentiles among school going children. Similarly the risk factors of childhood obesity also need to be understood to initiate necessary intervention strategies for the prevention and control of the menace at an early stage.

It is now generally accepted that overweight and obesity increase the risk of chronic diseases. Obesity is an important modulator of the metabolic syndrome which is a clustering of cardiovascular risk factors associated with insulin resistance such as hypertension, hypertriglyceridaemia, low concentration of high density lipoprotein cholesterol, abnormal glucose metabolism and hyperinsulinaemia (Abate, 2000). Hence it is envisaged that an understanding of childhood obesity and its associations with elevated blood lipids, lipoprotein levels, elevated blood pressure and other biochemical parameters, the known factors predisposing adult morbidity and mortality need to be investigated. Hence the study on 'Multiple correlates of obesity among school children' was undertaken with the following objectives.

Objectives

1. To determine the prevalence of overweight and obesity among the school going children aged between 7 to 12 years
2. To elicit information regarding the socioeconomic conditions and personal profile of school children

3. To understand the dietary habits and practices in general and food consumption pattern in particular of school children
4. To know the clinical picture and biochemical parameters of normal weight and overweight/obese children
5. To study the multiple correlates of obesity
6. To derive prediction index for childhood obesity

2. Review of Literature

The literature pertaining to the study on ‘Multiple correlates of obesity among school children’ is presented under the following heads.

2. 1. Definition of Obesity

Obesity is defined as an excessively high amount of body fat or adipose tissue in relation to lean body mass (Flegal *et al*., 2002a). Although definition of obesity and overweight has changed over the time, it can still be defined as an excess of body fat (BF) (Kuczmarski and Flegal, 2000). There is no consensus on a cut-off point for excess body fat in overweight or obesity in children and adolescents. For children, European researchers classified overweight as at or above 85th percentile and obesity as at or above 95th percentile of BMI (Flodmark *et al*., 2004). The Centre for Disease

Control and Prevention defined overweight as at or above the 95th percentile of BMI for age and "at risk for overweight" as between 85th to 95th percentile of BMI for age (Flegal *et al*., 2002b; Himes and Dietz, 1994). Williams *et al*., (1992) measured skinfold thickness of 3320 children aged 5 to 18 years and classified children as fat if their percentage of body fat was at least 25 per cent and 30 per cent, respectively, for males and females. When the body weight of individuals is more than 10 per cent of ideal body weight, the individual is overweight and 20 per cent more than ideal body weight, the individual is obese (Robinson and Weigley, 1991). Though CDC (Centres for Disease Control and Prevention, 2009), Khadilkar *et al*., (2007), Cole *et al*., (2000), McCarthy *et al*. (2001) and Must *et al*. (1999) have separately furnished the obesity percentiles for school going children, the values in every system are observed to show slight variations, demanding a closer examination and standardization.

2. 2. Prevalence of childhood obesity

2. 2. 1. Childhood obesity at global level

The problem of overweight and obesity is increasing alarmingly in both developed and developing countries. As given by Rorentino (2002) obesity is a condition that is associated with complications in both childhood and adulthood and rates of incidence are increasing worldwide. The problem appears to be increasing rapidly in children, with true health consequences fully apparent in the future. More than 300 million people worldwide are obese.

In Australia, the prevalence of overweight and obesity are increasing children by about one percentage every year. This equates to 40,000 more overweight children each year, placing Australian children among those at highest risk around the world.

In addition, girls are more likely to be overweight, and there is a general trend for children of lower socio economic status, to be at even greater risk of overweight and obesity (Sanigorski *et al*., 2007). Through a study conducted in Greece among children of 6 to 11 years, it was found that 27.8 per cent boys, were overweight, and 12.3 were obese. For girls, the corresponding values were 26.5 per cent for overweight and 9.9 per cent for obesity. There was an increase in the prevalence of overweight and obesity in the last 10 years in both sexes. For boys, overweight increased by 4.2 per cent and obesity by 2.9 per cent, whereas, for girls, overweight increased by 3.8 per cent and obesity by 1.6 per cent.

Overweight and obesity were less prevalent in the immigrant children compared with their Greek peers. For immigrant boys, overweight were 15.9 per cent and obesity was 7.9 per cent, and for immigrant girls, overweight were 15.2 per cent and obesity was 8.7 per cent. The prevalence of childhood obesity in other countries ranged from four per cent to 15 per cent, and that of overweight was double or triple that figure (Papadimitriou *et al*., 2006).

The growing obesity epidemic in the United States is threatening the health of millions of children. Dietz (2004) reported that overweight or obesity doubled in American children ageing 6 to 11 years and tripled in American adolescents ageing 12 to 17 years. A 75 per cent relative increase in obesity among adolescents was noted from 1970 to 1998 and 25 per cent of population was obese (Stic *et al*., 1999). At the age of 7 to 8 years, 15.7 per cent of children were overweight as per the International Obesity Task Force standards and of these overweight children, 85.5 per cent were overweight at the age of 13-14 also (Lee *et al*., 2004). During the past 20 years, obesity rates among children and adolescents have doubled and United States National Centre for Health Statistics reported that nearly 15 per cent are overweight or obese (Goindi *et al.*, 2003). National Health and Nutrition Examination Study (NHANES II – 1976 to 1980) showed that the prevalence of overweight in children has doubled from 7 to 15 per cent in 6 to 11 years old children and nearly tripled from 5 to 15 per cent in adolescents of 12 to 19 years old (Ogden *et al.*, 2002).

Till 1998, the prevalence of overweight has increased by more than 100 per cent among adolescents in the U.S. (Ogden and Chanana, 1998; Whitaker *et al.*, 1997) and this continued. Because preadolescents and adolescents who are overweight are likely to become overweight adults, it suggests that it is essential to target youth for obesity prevention messages and intervention programmes.

The prevalence of paediatric obesity is reaching alarming levels in the United States. The third National Health and Nutrition Examination Study showed that the percentage of 2 to 5 year old children with weight for stature above the 95^{th} percentile increased from 2.1 to 5.0 per cent in boys and 4.8 to 10.8 per cent in girls over a period of 6 years (Ogden *et al.*, 1997). Initial results from the 1999 National Health and Nutrition Examination Survey (NHANES) indicated that an estimated 13 per cent of children of 6 to 11 years age and 14 per cent of adolescents of 12 to 19 years age are overweight (defined as age and sex-specific BMI at 95^{th} percentile). From NHANES II (1976-1980) to NHANES 1999, the prevalence of overweight has nearly doubled (7 to 13 per cent) among children and has almost tripled (5 to 14 per cent) among adolescents (CDC, 1997).

In the United States, an estimated 15 per cent of 6-11 year old children are overweight (*i.e.*, they fall at or above the 95^{th} percentile of BMI for their age and sex). In USA, prevalence of overweight among 5 to 24 years has increased two fold between 1973 and 1994. Furthermore the yearly increase in relative weight and obesity during the later part of the study were approximately 50 per cent greater than those between 1973 and 1982 (Freedman, 1997).

In few ethnic and age subgroups, the prevalence has exceeded 60 per cent. This increase has occurred despite the efforts of health care providers and consumers alike, to improve the health-related behaviours of the population (Calle *et al*., 1999). American Indians of all ages and both sexes had a higher prevalence of obesity than the general U.S. population (Story *et al*., 1999; Broussard *et al*., 1995). Despite the continuous efforts to educate the public that excessive weight increases the risk of chronic diseases, the prevalence of overweight and obesity continues to increase (Flegal *et al*., 1998).

Overweight in children is a serious public health problem in U.K. also. Prevalence of overweight was five to six per cent in both 1974 and 1984 in white boys, and nine to ten per cent in white girls. It rose to nine to ten per cent in boys in 1994 to over 13 per cent in English girls and to nearly 16 per cent in Scottish girls. According to Chinn and Rona, (2001) the prevalence of obesity in children was low, but it has increased substantially since 1984. Overweight and obesity have registered a quick increase within the UK population among both adults and children in the last decade (Reilly *et al*., 1999). This trend is also being observed in other countries (Lazarus *et al.*, 2000; Moreno *et al*., 2000; Hanley *et al*., 2000; Toriano *et al*., 1995).

A similar trend has been observed in Japan, the frequency of obese school children (>120 per cent of standard body weight) aged 6 to 14 years increased from 5 to 10 per cent and that of extremely obese (>140 per cent of standard body weight) children from 1-2 per cent during the 20 years between 1974 and 1993 (Freedman, 1997).

The prevalence of obesity is increasing worldwide including some developing countries that previously had low prevalence (Sakamato *et al*., 2000; WHO, 2000).

Childhood obesity is not confined to the industrialized countries, as high rates are already evident in some developing countries. The prevalence of obesity among school children aged 6 to 12 years in Thailand as diagnosed by weight for height exceeding 120 per cent of Bangkok reference rose from 12.2 per cent in 1991 to 15.6 per cent in 1993 (Mc Swan *et al*., 1993). In a study of 6 to 18 years old male school children in Saudi Arabia, the prevalence of obesity was found to be 15.8 per cent (Alluaim *et al*., 1996).

2. 2. 2. Childhood obesity in India

Obesity in children and adolescents is gradually becoming a major public health problem in many developing countries, including India (Popkin and Doak, 1998). School based data on prevalence of overweight and obesity in India demonstrates an obesity range of 5.6 to 24.0 per cent for the children and adolescents. The prevalence is higher in urban than in rural areas (Kaur *et al*., 2005). In a study conducted at Hyderabad, the overall prevalence of overweight was 6.1 per cent among boys and 8.2 per cent among girls; 1.6 per cent and 1.0 per cent respectively of boys and girls were obese. The prevalence was significantly higher among adolescents who watched television 3 hours/ day (10.4 per cent) or belonged to a high socioeconomic background, whereas it was significantly lower among those participating regularly in outdoor games 6 hours/ week and household activities 3 hours/ day. The logistic regression analysis revealed that the prevalence of overweight was 4 times higher among the adolescents of high socioeconomic status, 3 times higher in those not participating in outdoor games and 1.92 times higher in those watching television 3 hours/ day (Laxmaiah *et al*., 2007). The results of studies among adolescents from parts of Punjab, Maharashtra, Delhi, and South India revealed that the prevalence of overweight and obesity was high (11 to 29 per cent). Urban children in the age group of 11 to 17 years of age were more overweight (11.6 per cent) than their rural counterparts (4.7 per cent), (Kaur *et al*., 2005). Another study carried out exclusively in Ludhiana, Punjab, on school children in the age group of 9 to 15 years revealed that the overall prevalence of overweight and obesity were 11 per cent and 14 per cent, respectively (Kaur *et al*., 2005). Singh *et al*., (2003) in their study conducted among 60 children of age 7 to 9 years who were 20 per cent above the normal weight, severe obesity was observed among 53.3 per cent, moderate obesity in 33.3 per cent and mild obesity in 13.3 per cent. Similarly, when 120 children (4-12 years) with excessive weight for age were studied, 90-100 per cent of children had BMI greater than 97^{th} centile (Sharma and Singh, 2003).

In Pune, Maharashtra, study among 1228 boys in the age group of 10 to 15 years indicated that 20 per cent were overweight, whereas 5.7 per cent were obese (Kaur *et al*., 2005). A similar study conducted in Chennai, showed a prevalence rate of overweight (17 %) and obesity (3 %) (Kaur *et al*., 2005).

Kapur and Sethi, (2003) conducted a survey of 664 school children in Delhi, and obesity was diagnosed in 7.8 per cent, indicating the high prevalence in urban areas. Another study on 1238 children aged 7 to 9 years in Delhi revealed that 6.22 per cent were obese with the prevalence of overweight being little higher of 8.24 per cent (Monga and Khanna, 2003). Yet another study carried out in Delhi, among 5000 private school children in the age group of 4 to 18 years in 2002 by the Nutrition Foundation of India reported that the prevalence of overweight was 29 per cent (Kaur *et al*., 2005).

2. 2. 3. Childhood obesity in Kerala

Although a majority of children in Kerala are underweight, the state is fast catching up with the West in childhood obesity (Maya, 2007). Varghese and Vijayakumar (2008) have reported an overall prevalence of obesity and overweight at 5.5 and 24.8 per cent respectively in general population in Kerala. They also found an increase in prevalence of overweight or obesity with age from 20 to 29 years to 50 to 59 years, showing a decline with age thereafter.

Prevalence of overweight and obesity among school going children in Thiruvananthapuram district indicated a comparative low prevalence of overweight among rural boys (8.31 %) than urban boys (21.3 %) for 10 to 15 years of age. For the same age group, the prevalence of overweight among rural and urban girls was 11.92 and 20.9 per cent respectively whereas the prevalence of obesity among urban boys and girls were 6.73 and 5.34 per cent respectively and among rural boys and girls, it was 2.93 and 2.25 per cent respectively (Unnithan and Syamakumari, 2008). Percentage and trends of overweight and obesity among 5 to 16 years old children in the private and government schools of urban and rural areas in Ernakulam district was studied by Raj *et al*., (2007). They found that the proportion of overweight children increased from 4.94 per cent of the total students in 2003 to 6.57 per cent in 2005. The increase was significant in both boys and girls. It was also noticed that the proportion of overweight children was significantly higher in urban regions and in private schools and the rising trend was limited to private schools. According to Ramachandran (2004), the prevalence of overweight and obesity among the school and college going students of urban and rural Thiruvananthapuram district was 5.4 per cent. A strong association of obesity with the family history including parents and siblings and lack of physical activity was also observed. There was distinct difference in the prevalence of obesity in rural and urban areas, the latter being more prone.

2. 3. Consequences of childhood obesity

2. 3. 1. Physical consequences

Childhood obesity is a matter of great concern in recent years as there are clear cut evidences to support the fact that adult obesity is nothing but an extension of childhood obesity. According to Singh *et al*., (2003) 30 per cent of all obese adults in India are reported to have been obese in childhood.

Obesity is particularly common among adults but is increasingly found among children and adolescents (Livingstone, 2001; Monteiro *et al*., 2004). As given by Palasciano *et al*. (1989) if a child is obese at 6 years of age, the chances of becoming an obese adult are 50 per cent and if an adolescent is obese, their probability of becoming an obese adult rises to 70 per cent. The dual effects of pre-existing morbidities and the probability of the excess weight persisting into adulthood markedly increase the risk of disease and premature death. The probability of obese children and adolescents to become obese adults has also been emphasised by Whitaker *et al*. (1997) and Serdula *et al*. (1993).

Adulthood obesity has been clearly shown to be associated with an increased risk of Type-II diabetes, hypertension, coronary artery disease, degenerative arthritis, gall bladder disease, a number of different cancers, and mortality (Cornier *et al*., 2002; Allison *et al*., 1999; Must *et al*., 1999). Pi-Sunyer, (1991) also observed that adults with obesity are at increased risk of coronary heart disease, diabetes, hypertension, dyslipidemia, gall bladder disease, osteoarthritis, and some cancers. Beside these, as (Pi-Sunyer, 1993) stated obesity during adulthood is an important risk factor for several chronic disease conditions, including musculoskeletal disorders, as well as all-cause mortality.

More than obesity, percent body fat is strongly associated with the risk of chronic diseases such as hypertension, dyslipidemia, diabetes mellitus, and coronary heart disease (Merchant *et al*., 2007; Dentali *et al*. 2005; Sharma and Chetty, 2005). The metabolic syndrome, operationally defined as the presence of any three of the following factors: central obesity (high waist circumference), hyperglycemia, high blood pressure, low high-density lipoprotein-cholesterol (HDLC), or high triglycerides, has recently been recognized as a public health concern in the United States (Ford *et al*., 2002). Intra-abdominal fat has been associated with adverse clinical effects, characterized by hyperinsulinemia, dyslipidemia, glucose intolerance, and hypertension, increasing the risk of diseases such as Type-II diabetes, cardiovascular diseases and some cancers (Han *et al*., 1995).

The physical health consequences of childhood obesity, until fairly recently, were largely unrecognized. In fact, there are few organ systems that severe obesity does not affect (Lobstein *et al*., 2004). Associated outcomes include: cardiovascular risk factors, identified in children as young as 5 years; type 2 diabetes; non-alcoholic fatty liver disease; asthma; sleep-disordered breathing, systemic inflammation; and orthopedic problems. There is a marked tendency for obesity, particularly adolescent obesity, to track into adulthood, and so be associated with adult obesity-related disorders. However, even after controlling for current risk factors including weight, childhood obesity is associated with increased risk of coronary heart disease mortality (Flynn *et al*., 2006; Smith, 2004; Reilly *et al*., 2003b; Dietz, 1998a and 1998b). Childhood obesity, according to Flegal *et al*., (2002a) is an important risk factor of Type-II diabetes, hypertension, and cardiovascular disease in adult life, has increased remarkably worldwide in the past decades.

Defining national prevalence of overweight and obesity in children is of obvious importance because it has been reported that more than 60 per cent of obese children have one or more cardiovascular risk factors such as hyperinsulinemia, glucose intolerance, dyslipidemia, or hypertension. There is also a clustering of these risk factors with increases in BMI and body fat. Overweight children are known to have higher fasting glucose levels (Callahan and Mansfield, 2000), and they produce more insulin after a glucose challenge (Pinhas *et al*., 1996). The impact of excess weight gain could be particularly important in Hispanic and African Americans, because healthy children from these ethnic groups are already reported to have lower insulin sensitivity than white children (Goran *et al*., 2002).

The newly emerging and increasing incidence of Type-II diabetes in children and adolescents has also been ascribed to the high prevalence of obesity (Young *et al*., 2000; Epstein *et al*., 1985). Gall bladder disease is a rare complication of childhood obesity. Childhood overweight results in adverse health effects, including cardiovascular disease (CVD) risk factors, diabetes, asthma during childhood, and a higher risk of obesity during adulthood (Gold *et al*., 2003; Dietz, 2001a). Obese children are at increased risk for a number of comorbid conditions, including hypertension, dyslipidemia (Freedman *et al*., 1999; Smoak *et al*., 1987) impaired glucose tolerance (Sinha *et al*., 2002), and obstructive sleep apnoea (Redline *et al*., 1999).

Faster and earlier childhood growth is seen in the development of obesity (Lenthe *et al*., 1996). Childhood obesity is not a disease in itself but rather a symptom for onset of adult obesity, with increased mortality, cardiovascular disease, atherosclerosis and diabetes. Ten to thirty per cent of obese adults are reported to be obese in their childhood. The probability of adult obesity increases with severity of childhood obesity, onset time in adolescence and a pre-existing pattern of family obesity (WHO, 1998).

The costs of the obesity epidemic have been estimated to account for up to 6 per cent of U.S. healthcare spending (Wolf and Colditz, 1998). On the other hand, there is evidence that central obesity is a significant predictor of the development of diabetes beyond that explained by obesity alone (Chan *et al*., 1994; Hartz *et al*., 1983). Fat distribution is a strong risk factor for morbidity and mortality (Larsson *et al*., 1984; Lapidus *et al*., 1984).

The age group of 7 to 9 year old can be selected for medical and practical reasons because at this age children are pre-pubertal (puberty would induce a significant variation in fat content between genders), and overweight in this age group is of value for predicting obesity (Serdula *et al*., 1993). A high weight gain (Stettler *et al*., 2003; Ong *et al*., 2000), parental overweight and obesity (Locard *et al*., 1992) lack of breastfeeding (von Kries *et al*., 1999a), parental education (Gnavi *et al*., 2000), high birth weight (Rasmussen and Johansson, 1998), having older siblings (Toschke *et al*., 2004), ethnic difference and maternal smoking in pregnancy (Gnavi *et al*., 2000; von Kries *et al*., 1999b; Vik *et al*., 1996) are predictors for later overweight or obesity. Overweight children are at increased risk of becoming overweight or obese adults, especially if they remain overweight during adolescence (Whitaker *et al*., 1997; Guo *et al*., 1994; Serdula *et al*., 1993).

Children who were obese or over weight had 80 per cent chance of becoming obese and overweight adults especially if parents have the same condition (Raj, 2004). The epidemic of childhood obesity is of concern because of the adverse consequences in short as well as long terms (Reilly *et al*., 2003b). The identification of risk factors is the key to prevention. Evidence on risk factors for childhood obesity is limited at present (Dietz, 2001a; Parsons *et al*., 1999) although awareness is increasing for the importance of the environment in early life. Prevalence of overweight and its related morbidity are increasing in industrialized countries (Koletzko *et al*., 2002; Bundred *et al*., 2001; Ogden *et al*., 1997). In obese children, interventions rarely show satisfying long term results (Feldman, 1994). Early identification of children at high risk for overweight might offer a chance for early preventive measures (Lederman *et al*., 2004). Early high weight gain has been identified as a predictor for later overweight (Stettler *et al*., 2002a; 2003).

Some of the physical consequences of obesity are gendered, with some evidence that adult mortality risks are higher in respect of adolescent obesity among males (Dietz, 1998a, 1998b). There have been suggestions of a stronger relationship between obesity and asthma in females, but results in this respect are inconsistent (Chinn, 2003; 2006). Among females, obesity is associated with early onset of puberty and menarche which have, in turn, been linked to breast cancer, although the relationships are complex (Stoll, 1998). Obesity has also been related to other cancers of the female reproductive system, increased risk of spontaneous abortion and menstrual problems, particularly polycystic ovary syndrome which can lead to infertility (Slyper, 2006a). The relationship between obesity and female puberty led to the suggestion that a threshold level of fatness is required for the female growth spurt and menarche.

Presently, this is not considered to be the case (Slyper, 2006b; Dunger *et al*., 2005) and indeed, there is a growing body of evidence suggesting the opposite, that puberty affects levels of fatness. Links have also been suggested between increasing levels of obesity, its association with female puberty and claims of recent reductions in age of menarche. Reviews conflict, some suggesting 'clear evidence' that the age of menarche is falling (Ebling, 2003) and others that while menarche may be stable, the first signs of puberty, such as breast budding may now be occurring earlier (Slyper, 2006b; Dunger *et al*., 2005). However, it may be the case that there has been no recent secular change in either, but rather that obesity is associated with premature development of pubic hair and apparent breast tissue separate from true puberty (Viner, 2002). Since markers of puberty are more overt and recordable for females, there is less information about its timing for males (Ebling, 2003). However, some reviews of obesity and puberty appear to extrapolate the female findings to males or children/ adolescents in general (Dunger *et al*., 2005). In fact, although the evidence is much sparser, there is some evidence that in males, obesity is associated with later sexual maturation (Wang, 2004).

Bio chemical profile in childhood obesity

Garce’s *et al*., (2005) observed that, in both sexes, obese children had higher triglycerides and lower high-density lipoprotein-cholesterol levels than non-obese children. No differences were found in plasma glucose or low-density lipoprotein-cholesterol levels between normal and obese children. Insulin levels and the homeostasis model assessment for insulin resistance were significantly higher in obese children of both sexes but that free fatty acid levels were lower in obese children than in non obese children, with a statistical significance in girls.

Some metabolic consequences of obesity similar to those found in adults (elevated triglycerides, insulin, and the homeostasis model assessment for insulin resistance, and lower high-density lipoprotein-cholesterol) were seen among children.

However, other features (glucose, total cholesterol, low density lipoprotein-cholesterol, and free fatty acid levels) were found to behave differently, indicating that the association of obesity with risk factors seems to change as the children age and may depend on the chronology of sexual maturation. In childhood, obesity also seems to lead to the appearance of a number of cardiovascular risk factors, such as altered lipid levels (Friedland *et al*., 2005) and impaired glucose tolerance (Sinha *et al*., 2002), which could contribute to atheroma plaque development and lead to the development of coronary heart disease in adult life (Freedman *et al*., 2001).

2. 3. 2. Psycho social consequences

The immediate psychosocial consequences of childhood and adolescent obesity have been long-recognized (Bruch, 1941). Stigmatization and discrimination by peers is well-documented from very young ages, obese children are characterized in negative ways, less preferred as friends and more likely to be the targets of teasing or bullying (Dietz, 1998a). There is also evidence of bias and stereotyping by teachers and even some parents. While it could be argued that such behaviours might diminish as obesity becomes more common, this does not appear to have occurred (Lobstein *et al*., 2004).

Latner *et al*., (2007) also reported that stigmatization of overweight children is highly prevalent. The settings and sources of stigmatization are multiple and varies including peers (Eisenberg *et al*., 2003), family members (Neumark-Sztainer *et al*., 2002; Crandall, 1991), and even educators (O'Brien *et al*., 2007; Neumark-Sztainer *et al*., 1999 and Canning and Mayer, 1966). The stigma against overweight children appears to have increased over the past four decades (Latner and Stunkard, 2003), despite the increase in prevalence and the increased visibility of childhood obesity

(Wang and Lobstein, 2006). Weight stigma may have numerous negative effects. For example, weight related teasing can increase risk of later eating disturbances (Thompson *et al*., 1995).

Childhood obesity has considerable social and psychological consequences within childhood and adolescence (Reilly *et al*., 2003b). The effect of childhood obesity results in persistent child and adult or adult onset obesity and poorer socio-economic and educational outcomes. Obesity related health inequalities and social adversities develop after childhood (Viner and Cole, 2005). It results in poorer quality of life, low self-esteem, depression and poor academic achievement within childhood and adolescence (Gortmaker *et al*., 1993).

Evidence in respect of the psychological consequences of child and adolescent obesity is mixed. While some reviews conclude that it is associated with psychological or psychiatric problems, increasing with age and particularly among girls, others suggest that research has failed to find consistent differences in the global self esteem (Reilly *et al*., 2003b), depression or anxiety (Friedman and Brownwell, 1995) of obese or overweight children and adolescents compared with the rest of the population. Such conflicting results may have arisen in part because obese clinic samples tend to have poorer psychological well-being and quality of life than community samples.

Wardle and Cooke, (2005) also opined that childhood obesity is associated with several negative psychological outcomes. The weight loss treatment programmes are reported to improve self esteem in children and adolescents (French *et al*., 1995).

While obese community samples have lower body satisfaction and physical self-competence than non-obese, few are depressed or have low global self esteem (Flodmark, 2005; Wardle and Cooke, 2005). Small differences in their psychological well being may also be explained, at least partly, by weight related teasing or bullying (McElroy *et al*., 2004). There have been suggestions of associations between depression and obesity and that major depression in adolescents, or young females, predicts increased adult BMI (McElroy *et al*., 2004; Stunkard *et al*., 2003). However, the relationship between obesity and depression has been described as unproved (Wardle and Cooke, 2005). Reductions in body satisfaction and wellbeing amongst the obese are greater among adolescents than children and among females than males.

Gender differences in body satisfaction emerge around 8 to 10 years of age (Ricciardelli and McCabe, 2001). While both males and females with a high BMI wish to be thinner, the picture is more complex for males because of the larger muscular male ideal. In relation to stereotypes and attitudes, some studies have demonstrated equivalent stereotyping of obese peers, regardless of gender. However others have suggested that females express stronger dislike of obese peers than males, and that obese females are rated more negatively than obese males. There is also some evidence that females may be more vulnerable to obesity related victimization, but again, this is not a consistent finding (Puhl and Latner, 2007; Pine, 2001). The picture in relation to body satisfaction and obesity is also complicated by ethnic differences. For example, black girls with high BMIs are less likely than those from other ethnic groups to consider they overweight or desire to be thin (Puhl and Latner, 2007; Bronner, 1996).

Persistent child to adult obesity is associated with somewhat poorer employment and relationship outcomes in women. Only health inequalities and social adversity related to obesity probably develop after childhood (Reilly *et al*., 2003b). Persistent obesity was not associated with any adverse adult outcomes in men, though it was associated among women with a higher risk of never having been gainfully employed and not having a current partner. Gortmaker *et al*., (1993) found that US women who had been obese in late adolescence in 1981 were less likely to be married and had lower incomes seven years later than women who had not been overweight, while men who had been overweight were less likely to be married. Sargent and Blanchflower, (1994) found that UK women, but not men, who had been obese at 16 years in 1974, earned 7.4 per cent less than their non-obese peers at age. Adult obesity was associated with higher risk of psychological morbidity in women, poor educational achievement in men, and limiting longstanding illness in both sexes, but also with positive social (marriage and relationship) outcomes in men.

Efforts to reduce socio-economic and psychosocial burden of obesity in adult life should focus on prevention of the persistence of obesity from childhood into adulthood (Viner and Cole, 2005). For children, the parent is the primary mediator of change and a family based intervention is essential since parenting style is an integral part of how parents approach the feeding relationship (Jeor *et al*., 2002). Since the early 1990s, numerous school-based dietary and physical activity promotion programmes have been developed, implemented, and evaluated across nations and many decreased BMI among intervention students (Robinson, 1999; Gortmaker *et al*., 1999; Flores, 1995; Lionis *et al*., 1991; Killen *et al*., 1988; Dwyer *et al*., 1983). Despite the alarming trends in the development of paediatric obesity, only few intervention efforts have focused on prevention. An examination of the paediatric obesity treatment literature shows that one of the best predictors of short and long term weight regulation for children of 8 to 12 years age is parental involvement (Epstein, 1996).

Gender differences in weight control methods are observed by Robb and Dadson, (2002). Males are more likely to exercise, begin dieting at a higher BMI than females, and tend to focus on increasing upper body size while reducing fat. In contrast to professionally administered, sensible weight loss programmes, (Butryn and Wadden, 2005). The use of unhealthy quick-fix dieting practices by some adolescents has been linked to a range of negative physiological and psychological outcomes (Potter *et al*., 2004; Daee *et al*., 2002). Although such behaviours are significantly more likely among females (Irving and Neumark-Sztainer, 2002; Peixoto, 2002) males are not immune to disordered eating behaviours. The finding of one study that femininity as represented by self ascribed expressive personality traits was predictive of eating problems among both male and female adolescents, highlights the need to consider such characteristics within each gender, rather than just compare the behaviours of males and females (Wichstrom, 1995). To return to the longer term consequences, longitudinal studies in both the US and UK have demonstrated that child and adolescent obesity is associated with adverse social and economic outcomes such as reduced years of education, income and marriage rates in young adulthood. Again, there are gender differences, these effects being stronger for females (Reilly *et al*., 2003a; Fulton *et al*., 2001; Dietz, 1998a).

2. 4. Multiple correlates of obesity

2. 4.1. Biological correlates

Intrauterine life, infancy and pre-school period

Intrauterine life, infancy, and the preschool period have all been considered as possible critical periods during which the long term regulation of energy balance may be programmed. Future interventions may be programmed with focus on environmental changes targeted at relatively short periods in early life, attempting to modify factors *in utero*, in infancy or in early childhood, which are independently related to later risk of obesity (Reilly *et al*., 2005). Intrauterine life as a critical period for the development of obesity in later life is also pointed out by Dietz (1994).

Birth weight and related factors

A high prevalence of obesity for the lowest and highest birth weight suggesting a more complex association between growth in uterus and obesity is reported by various longitudinal studies (Seidman *et al*., 1996; Hulman *et al*., 1998). Growth *in utero* is summarised, albeit crudely, by birth weight, which, if related to fatness later in life, might implicate the foetal environment in the development of obesity. The relation between birth weight and fatness, measured in childhood or adulthood, is generally positive, although it is variable in magnitude (Parsons *et al*., 1999). A possible reason for this variability is that the strength of the relation may depend on the age at which fatness is measured. More importantly, several factors, such as gestational age, parental body size, and socioeconomic status, may confound the relation between birth weight and later fatness (Whitaker and Dietz, 1998).

The increase in the prevalence of overweight could not be explained by time trends in the distribution of birth weight or by changes in the association between birth weight and the later risk of overweight over time. This implies that, unless the prenatal environment influences the later risk of overweight without increasing birth weight, the environmental influences contributing to the obesity epidemic in children of school age operate in the early postnatal period (Rugholm *et al*., 2005). The consistency and robustness of the relationship between rapid infant weight gain and the increased odds of childhood overweight supports infancy as a critical period of increased susceptibility for becoming overweight (Dennison *et al*., 2006). Early infancy has been identified as one such critical period. Several studies suggest an association between increased rates of weight gain during the first 4 to 24 months of life and risk of overweight during later childhood or early adulthood (Toschke *et al*., 2004; Stettler *et al*., 2003, 2002b; Ong *et al*., 2000).

A ‘J’ or ‘U’ shaped relation, with a higher prevalence of obesity seen for the lowest and highest birth weights is also reported (Hulman *et al*., 1998; Seidman *et al*., 1996; Curhan *et al*., 1996; Fall *et al*., 1995). Increasing birth weight was independently and linearly associated with increasing prevalence of obesity at age 7. Obesity at age 7 was also significantly associated with maternal smoking between 28 and 32 weeks’ gestation. Sex, parity, season of birth, gestational age, number of fetuses, timing of introduction of complementary feeding, number of siblings, ethnicity, maternal age and time spent in the car were not independently associated with the risk of obesity in childhood (Reilly, 2005). The precise mechanisms by which the early life growth variables studied in the children in focus sub-sample might increase the risk of obesity are generally unclear. They are, however, consistent with the increasing evidence that the early life environment is an important determinant of risk of obesity in later life (Armstrong and Reilly, 2002; Dietz, 2001b; Ong *et al*., 2000).

Breast feeding

In industrialised countries promoting prolonged breast feeding may help decrease the prevalence of obesity in childhood. Since obese children have a high risk of becoming obese adults, such preventive measures may eventually result in a reduction in the prevalence of cardiovascular diseases and other diseases related to obesity (von Kries *et al*., 1999a). Lucas *et al*., (1981) found significantly higher plasma concentrations of insulin in infants who had been bottle fed than in infants who had been breast fed;

these higher concentrations would be expected to stimulate fat deposition and the early development of adipocytes. Breast milk also contains bioactive factors which may modulate epidermal growth factor and tumour necrosis factor á, both of which are known to inhibit adipocyte differentiation *in vitro* (Hauner *et al*., 1995; Petruschke *et al*., 1994). The amount of energy metabolised and the protein intake of breastfed children is considerably lower than previously assumed and significantly below the intake of infants who are fed formulas Whitehead (1995) and Heinig *et al*., (1993). In longitudinal studies a significant relation was found between dietary protein intake at the age of 10 months and later body mass index and the distribution of body fat (Deheeger *et al*., 1996; Cachera *et al*., 1996) which suggests that a high intake of protein in early childhood might increase the risk of obesity later.

Genetic factors

A large number of factors both proximal and distal to the individual have been identified as contributing to the increasing prevalence of overweight among youth, including genetic, familial, socioeconomic, psychosocial, behavioural, and environmental factors (Davison and Birch, 2001). Childhood obesity results from an interaction between genetic and environmental factors, leading to positive energy balance and increased body adiposity (Swinburn *et al*., 2000). Quantifying genetic and environmental influences on health outcomes is challenging. Genetic factors affect physiological processes related to physical activity (Perusse *et al*., 2003) and weight (Comuzzie and Allison, 1998; Bouchard, 1996), but epidemiological studies of environment effects typically do not account for genetic predisposition. The extent to which genes contribute to body size, exercise, and/or food preferences is widely debated. For example, an estimated 50 to 90 per cent of variability in adiposity is attributable to genetics (Maes *et al*., 1997). The genetic contribution may be intensified through assortative mating between obese individuals, with obese genes being increased in the offspring (Hebebrand *et al*., 2000).

Like height, weight is heritable. One recent review suggests that twin and adoption studies point to a genetic contribution for BMI of 40 to 70 per cent (Farooqi, 2005), while a more extensive, but earlier, review of familial resemblance suggests that genetic factors explain 50 to 90 per cent of BMI (Maes *et al*., 1997).

Parental obesity may increase the risk of obesity through genetic mechanisms or by shared familial characteristics in the environment such as food preferences (Francis *et al*., 2003). The risk of being obese is more when one parent is obese and risk was higher when both parents were obese. Maternal weight or Body Mass Index (BMI) largely explains the association between birth weight and adult body mass index and it may be a more important risk factor for obesity in the child than birth weight. Intergenerational associations between the mother's and her offspring's body mass index seem to underlie the well documented association between birth weight and body mass index. Other measures of fetal growth are needed for a fuller understanding of the role of the intrauterine environment in the development of obesity (Parsons *et al*., 2001).

2. 4. 2. Life style correlates

Physical activity

The results of the study conducted in Hyderabad (Laxmaiah *et al*., 2007) clearly revealed that regular physical activity was an important factor in reducing prevalence of overweight and obesity. The prevalence was significantly lower in the children who participated regularly in household chores, played outdoor games, and performed physical exercise. The diets of the children in the higher socioeconomic group are known for their higher fat content, and the subjects are involved in more sedentary activities. These observations are consistent with results of previous studies (Patrick *et al*., 2004). A physical activity intervention had no effect on body mass index or habitual physical activity. The intervention improved movement skills, which may increase future participation in physical activity or sports. Alternative interventions to prevent obesity in young children are required (Reilly *et al*., 2006).

Sedentary behaviour has also been associated with body composition and BMI. Reduction in physical activity is ascribed as one of the major causes for the increased energy imbalance among children (Steinbeck, 2001; Hill and Peters, 1998). Approximately 80 per cent of students in junior high school (12-15 years of age) in Japan have been reported to live a sedentary lifestyle outside of school (Murata, 2000; Committee on the Surveillance Project on the Condition of Children's Health, 1998).

Environmental and Cultural Influences

The increasing trends in obesity, especially among children living in rural areas, could be the result of environmental and cultural changes that lead to low levels of physical activity in rural settings.

Lifestyle behaviours targeted in weight control programmes are influenced by cultural variables that may reflect both the mainstream culture and the culture of the specific ethnic group or groups with which the person identifies (Kumanyika and Morssink, 1997). Examples of relevant attitudes and behaviours include general health beliefs and practices as well as those related to eating, exercising, body image, and dieting. The mainstream and ethnicity-specific influences may differ substantially, and the cultural perspectives associated with ethnicity may vary according to both acculturation and cultural identity (Landrine and Klonoff, 1994). Cultural identity manifested as attitudes, beliefs, and behavioral norms shared among persons from the same ethnic background is strongly related to the development of obesity (Gurung and Mehta, 2001; Phinney, 1990). African-American girls and women experience less social pressure about their weight and tend to be more satisfied with their bodies, and have less negative attitudes about overweight compared with white girls and women (Becker *et al*., 1999; Stevens *et al*., 1994; Harris, 1994; Kumanyika *et al*., 1993).

Television viewing

It appears that gains can be made in obesity prevention through restricting television viewing. Although, it seems that reduced eating in front of the television is at least as important as increasing activity (Robinson, 1999). Fast foods are one of the most advertised products on television and children are often the targeted market (Dehghan *et al*., 2005). For example, children who watch more television have been shown to have higher skin-fold thicknesses, while one study has suggested that approximately 17 per cent of early adult overweight may be attributable to watching TV for two or more hours daily in childhood (Wareham *et al*., 2005).

Television ownership and television watching have also grown remarkably (Russell *et al*., 2005). Television viewing may confer risk through a reduction in energy expenditure because watching television is associated with dietary intake, or because large amounts of time spent sedentary may contribute to impairment of the regulation of energy balance by uncoupling food intake from energy expenditure (Robinson, 1999; Gortmaker *et al*., 1996). Cross-sectional and longitudinal studies have shown that obese children spend less time in moderate and vigorous physical activity and that children who engage in the least vigorous physical activity or the most television viewing tend to be the most overweight (Trost *et al*., 2003; Robinson, 1999). In addition, the prevalence of overweight and obesity were higher among children who were involved in sedentary activities such as spending 3 h/d on television viewing (NCAER, 2001). Klesges *et al*. (1993) also reported the effect of watching television on metabolic rate and overweight and obesity in children. In urban areas, considering the safety of keeping children away from heavy traffic, parents feel more comfortable if their children play indoor games or watch television and therefore, do not encourage them to participate in outdoor sports and games.

Duration of sleep

High sleep duration, sedentary behaviour and junk food type dietary pattern was significantly associated with risk of obesity, Duration of night time sleep may alter later risk of obesity through growth hormone secretion, or because sleep reduces the child's exposure to factors in the environment that promote obesity, such as food intake in the evening. Alternatively, duration of night time sleep may be a marker for some other variable such as level of physical activity that is, children who are more physically active may sleep longer at night (Stettler *et al*., 2002b).

2. 4. 3. Dietary correlates

Childhood obesity arises from long-term poor regulation of energy balance; however, the energetics for the development of childhood obesity is poorly delineated. The energy imbalance required for weight gain from increased energy intake and/or decreased physical activity in children remains uncertain (Butte *et al*., 2007). A study to evaluate the effect of a parent-focused behavioural intervention on parent and child eating changes and on percentage of overweight changes in families showed that the effect of a parent-focused behavioural intervention on parent and child eating decreased the percentage of overweight in families (Epstein *et al*., 2001).

The transition in dietary patterns and lifestyles toward high-energy dense foods and sedentary lifestyles, the nutrition transition (Popkin, 2001), has led to alarming increases in the prevalence of obesity in developing countries.

Excessive weight during childhood stems from several interacting factors, including poor diet and exercise habits. Dietary preferences and physical activity patterns are probably shaped early in childhood, influenced by parental practices and familial environment (Hill and Trowbridge, 1998). It follows that obesity prevention programs, to be successful, will require parental participation (Baughcum *et al*., 2000). Dietary factors play a key role in the development and maintenance of overweight. Examination of National Health And Nutrition Examination Surveys (NHANES) III (1988 to 1994) data showed that mean energy intake was highest among African-American compared with non-Hispanic white and Hispanic girls 6 to 11 (1873 vs. 1765 and 1414 kcal, respectively) and 12 to 19 (2060 vs. 1948 and 1901 kcal, respectively) years old. Differences were also observed for percentage of energy from fat, with black girls showing higher percentages of energy from total fat compared with white girls 6 to 11 years old (34.6 per cent vs. 33.3 per cent, respectively) and African-American and Hispanic girls 12 to 19 years old (36.5 per cent vs. 33.6 per cent and 33.8 per cent, respectively) (Sherwood *et al*., 2004).

Findings from National Growth and Health Study show that African-American girls were more than twice as likely to engage in weight-related eating practices (i.e., eating in front of television, eating alone, snack food, skipping meals) compared with their white counterparts (Mc.Nutt *et al*., 1997). National Growth and Health Study findings also showed that African-American girls had lower intakes of calcium and potassium and higher intakes of vitamins, fat, and calories (Crawford *et al*., 1995).

The prevailing national perception of parents and their children seems to be that the availability of soft drinks and high-fat foods is a manifestation of improved circumstances and affluence, and there is little recognition of the hazards of overweight in either children or adults. Given the national decades-long concern to obtain enough food and to feed children adequately, it is little wonder that food consumption patterns have changed markedly over the last 10 years, with substantial increases in fat and sugar intakes (Navarro *et al*., 2004). Between 1970 and 1997, the United State Department of Agriculture (USDA) surveys indicated an increase of 118 per cent of per capita consumption of carbonated drinks, and a decline of 23 per cent for beverage milk (Putnam and Allshouse, 1999). Soft drink intake has been associated with the epidemic of obesity (Ludwig *et al*., 2001) and Type II diabetes (Gittelsohn *et al*., 1998) among children. While it is possible that drinking soda instead of milk would result in higher intake of total energy, it cannot be concluded definitively that sugar containing soft drinks promote weight gain because they displace dairy products. A targeted, school based education programme produced a modest reduction in the number of carbonated drinks consumed, which was associated with a reduction in the number of overweight and obese children (James *et al*., 2004).

Obesity is related to an imbalance between energy input and output, the size of which may be very small if continued over a long period (Reilly *et al*., 2007). One review suggests that in children, an imbalance of around 2 per cent, which is the equivalent of around 30 calories or 15 minutes of television instead of play a day, may lead to obesity (Goran, 2001). Behavioural determinants therefore include excess energy intake and/or inadequate energy expenditure (Prentice and Jebb, 1995) In respect of energy intake, dietary surveys do not suggest a secular increase among children and adolescents. However, the results of such studies may be confounded by an increasing trend towards greater under-reporting, to the extent that reported intake may be below the estimated required physiological minimum, especially among older girls. Regular consumption of high energy-dense fast foods and sugary drinks which are associated with less satiation and so insufficient compensation via subsequent reductions in intake, increased portion size, eating outside the home and snacking have been particularly implicated in promoting weight gain. This is especially the case among older children, who are less influenced by biological cues of satiety (Rennie *et al*., 2005; Agras and Mascola, 2005).

Females are more likely to pay attention to foods as a way to influence health and to meet nutritional recommendations, while males eat more fast foods. It has been suggested that these differences arise not only because of differences in Western societies' perception of ideal body weights, but also because some foods are gendered; for example meat may represent strength and virility. Gender differences in energy expenditure can also be attributed to both biological and social factors (Keith *et al*., 2006).

2. 5. Assessment of obesity

Field based methods and hospital based methods are available for measurement of obesity. But there is a lack of consistency and agreement for the classification of obesity in children as well as adults (Freedman, 1997).

2. 5. 1. Field based techniques

Weight and Height

According to Rao and Vijayaraghavan (1996) nutritional anthropometry is measurement of human body at various ages and levels of nutritional status. It is based on the concept that an appropriate measurement should reflect any morphological variation occurring due to a significant functional physiological change. Measurements of weight at various ages have been used as an index of nutritional status. Among the environmental factors, which influence the height of an individual, nutrition and morbidity are very important because inadequate dietary intake or infections reduce nutrient availability at cellular level leading to growth retardation and stunting. Tallness is significantly associated with increased obesity risk in children, while stunting is also associated, but to a lesser degree (Kain *et al*., 2005).

Weight-for-age percentiles cannot be used as surrogates for BMI-for-age percentiles to screen for overweight among children and adolescents. In the circumstances where height is not available, such as existing databases, some of the weight-for-age percentile cut-off points can be used as screening tools to identify population subgroups more likely to be overweight (Stettler *et al*., 2007).

Body Mass Index

BMI is a commonly used measure of body fat. Global cut-off points for overweight (25.0 kg/m2) and obesity (30.0 kg/m2) have been set by the World Health Organization (WHO, 1998). Since 1999, much debate has surrounded the appropriateness of these cut-off points in Asian populations. Several studies conducted in China (Zhou *et al*., 2002; Jia *et al*., 2002), Japan (Chang *et al*., 2003) and Hong Kong (Lee *et al*., 2002) have reported an association between a BMI 22.3 kg/m^2 and increased atherogenic risk factors.

Using data collected in the 1998 Korean Health and Nutrition Examination Survey, Kim *et al*., (2004) reported that the prevalence of diabetes, hypertension, and dyslipidemia has doubled at a BMI of 23.0 to 24.0 and tripled at a BMI of 26.0 in the adult population. The authors proposed that body fat and fat distribution at a BMI of 23.0 in Asians may be similar to those in whites at a BMI of 25.0. At the same BMI (Deurenberg *et al*., 2002a; Park *et al*., 2001), Asians have a higher percentage of body fat and more visceral adipose tissue compared with whites and African Americans. The health risks of excess body fat for adults have traditionally been associated with inappropriate weights for height. Tables of such weights for different frame sizes were originally derived from insurance data. Various indices based on weight and heights were then suggested as correlates of total body fat, but the Body Mass Index became the most widely accepted.

Since the early 1980s, John Garrow's classic chart based on BMI has been used extensively to assess the health risks of obesity. Healthy weight for height was defined in UK as a BMI between 20 and 25, overweight as more than 25 and less than 30, and obesity as BMI 30 and above. Even the USA has now adopted the same BMI categories as the rest of the world. BMI has served as a proxy for obesity for many years, but it has always been recognised that it does not differentiate between the over-muscled and the over-fat. The major problem with BMI is that even in the over-fat, it is only a proxy for total fat in the body and it does not distinguish between individuals with different types of fat distribution (Garrow, 1981).

Liu and Manson (2001) were also of the opinion that adult definitions of overweight and obesity are fairly arbitrary and have a number of weaknesses.

Primarily, BMI cutoffs that define adult overweight/ obesity have been chosen primarily for convenience: a substantial body of high quality evidence shows that health risk increases with increasing BMI even below these cutoffs (Liu and Manson, 2001). Secondly, BMI is a crude measure in adults, and screening for the fattest individuals using BMI is relatively poor (low sensitivity), particularly in women (Hortobagyi *et al*., 1994). Thirdly, adult measures of obesity based on fat distribution rather than on BMI may be more informative. Finally, universal definitions of obesity ignore clinically significant population differences in the relationships between BMI and adiposity or in the relationships between BMI and morbidity (Deurenberg, 2001).

Assessing pediatric obesity is not as straightforward as it may seem, but there is now a consensus that body mass index (BMI) should be used for clinical practice and epidemiology (Cole and Cachera, 2002; Barlow and Dietz, 1998). However, BMI values in children are much lower than in adults, and BMI changes with age, so BMI cutoffs to define obesity in adults are not appropriate for children. So the interpretation of BMI in children requires cutoffs applied to the BMI distribution (Barlow and Dietz, 1998).

Assessing body mass index in children using cutoffs that are different from those for adults was also suggested by Reilly and John (2002). A position statement on child health care in England recommends that BMI is assessed by comparison with international reference data, not national reference data (Hall, 2002). Another serious concern is the evidence that the ability of BMI to screen for the fattest children differs between population groups (Ellis *et al*., 1999; Daniels *et al*., 1997). In addition, a substantial body of high quality evidence has demonstrated that cutoffs based on national reference data are related to measures of morbidity (Morrison *et al*., 1999; Freedman *et al*., 1999; Dietz, 1998a).

A challenge in assessing the impact of obesity on health and health care costs is how to measure obesity itself. Body mass index (BMI) has been widely accepted and used in most epidemiological studies as a surrogate measure of total body fat. This formula takes into account not only body weight but also height. BMI, however, does not take into consideration the distribution of body fat, which is believed to have significant health implications. Abdominal adiposity has been independently associated with coronary artery disease, cerebrovascular disease, insulin resistance, and diabetes mellitus (Fujimoto *et al*., 1999; Rexrode *et al.*, 1998; Carey *et al.*, 1997). A number of studies have shown that high BMI is associated with increased total health care costs, increased health services use; increased days lost from work, and increased disability (Quesenberry *et al*., 1998; Burton *et al*., 1998; Wolf and Colditz, 1998 and 1996; Heithoff *et al*., 1997).

Waist circumference

Waist circumference (WC) is an easy measurement that is highly correlated with abdominal or visceral adiposity (Lemieux *et al*., 1996) and with markers of cardiovascular disease risk such as blood pressure, insulin resistance/ diabetes, low high-density lipoprotein cholesterol, and hypertriglyceridemia (Reeder *et al*., 1997; Ledoux *et al*., 1997a and 1997b). BMI gives no indication of fat distribution hence it is suggested to be a less sensitive indicator of fatness among children (Reilly *et al*., 2000). Until recently, waist circumference in children had not been regarded as an important measure of adiposity. During growth in childhood body fat is laid down both subcutaneously and intra-abdominally (Brambilla *et al*., 1994). In view of the observed relationships between waist circumference, intra-abdominal fat deposition and cardiovascular disease risk factors in children, waist circumference could be adopted as an alternative or additional measurement to BMI in children (McCarthy *et al*., 2001).

Excessive visceral adiposity as measured by anthropomorphic measures may be more closely associated with adverse health consequences than body weight or body mass index (BMI), the more commonly obtained clinical measures. Obesity as Body Mass Index equal to or greater than the 95th centile, equivalent to a Standard Deviation score of 1.64 or more. This definition has high specificity and moderate sensitivity for identifying the children with highest body fat percentage within the British population (Reilly *et al*., 2002; 2000). Obesity defined in this way is also biologically meaningful as it identifies those children who are most likely to experience co-morbidity, such as persistence of obesity, presence and clustering of cardiovascular risk factors, and psychological problems.

Evidence supporting the use of BMI and waist circumference (WC) measurements in the primary prevention of chronic diseases is mounting. The use of BMI and WC in predicting health risk has been recognized by the U.S. National Heart, Lung and Blood Institute of the NIH and Health Canada. The NIH and Health Canada clinical guidelines for identifying and managing obesity indicate that health risk increases in a graded fashion when moving from normal weight to obese BMI categories and that within each BMI category, individuals with high WC values are at a greater health risk than those with normal WC values (Health Canada, 2003; NIH, 2000). Despite these limitations, it has recently been confirmed that the NIH and Health Canada WC thresholds predict increased health risk within normal weight, overweight, and Obese Class-I BMI categories (Ardern *et al*., 2003; Janssen *et al*., 2002b).

In epidemiological studies, surrogate measures of body fatness such as BMI, waist circumference, waist hip ratio and skin fold thickness have been used extensively. However, these techniques do not precisely characterize persons by body composition (percentage of body fat or muscle mass), and there is substantial variation across age, sex and ethnic groups (Dagenais *et al*., 2005; Wang *et al*., 2000 and Womersley, 1977).

Lean *et al*., (1995) first proposed the use of waist circumference as part of clinical cardiovascular risk assessments and interpretation of health risks associated with adiposity. Waist circumference (WC) provides information about regional adiposity and may correlate with health care costs better than body weight or BMI (Grunwald and Daniel, 2002). Excessive abdominal adiposity as assessed by WC is associated with increased total health care charges, especially in the charges of inpatient care. WC may also be a better predictor of health care costs than the more widely used BMI. These findings offer more support that obesity, specifically abdominal adiposity, is associated with significant costs to the health care system and therefore more effort should be placed on the evaluation and treatment of this disease. The standardized use of anthropometric measurements has recently been advised for the prediction of health risks in primary care and private practice (Seidell *et al*., 2001). Because of the difficulty in calculating and explaining BMI scores to patients, WC has been recommended as a single measure of cardiovascular and metabolic health risk (Dobbelsteyn *et al*., 2001). However, the U.S. NIH has recommended a two-tiered classification system using both BMI and WC (NIH, 2000). Waist circumference has been suggested as a simple clinical alternative to BMI for detecting adults with possible health risks due to obesity (Seidell *et al*., 2001). Lean *et al*., (1995) first proposed the use of waist circumference (WC) as part of clinical cardiovascular risk assessments and interpretation of health risks associated with adiposity. The measurement of waist circumference alone may reflect the abdominal fat mass (Han *et al*., 1997) and may indicate a need for weight management (Lean *et al*., 1995).

Previously, waist circumference alone (WHO, 2000; SIGN, 1996) or BMI and waist circumference in combination (NIH, 1998) were implemented in guidelines for assessment and treatment of overweight and obesity in adults (WHO, 2000). Few prospective studies have addressed the relationship between waist circumference and all-cause mortality, and the results have been inconsistent (Baik *et al*., 2000; Folsom *et al*., 1993). Percentage of fat and waist circumference cut-points in pre-pubertal children with the intention of defining obesity associated with cardiovascular disease (CVD) risk, was conducted by (Higgins *et al*., 2001). Two cut-points, an upper cut-point of 33 per cent body fat and a lower cut-point of 20 per cent body fat, were derived. Waist circumference cut-points indicative of adverse and normal risk-factor profiles were 71 cm and 61 cm, respectively.

Although percent fat is a useful measure of overall adiposity, health risks are best represented by the simply measured WC (Shen *et al*., 2006). Power *et al*. (1997) suggested that an ideal measure for childhood obesity should meet the following criteria: the simplicity of the measure, the cost, ease of use, and acceptability to the subjects. A range of ratios using weight and height, such as the Rohrer index and conicity index (Taylor *et al*., 2000), are not in common use. BMI for age and gender has been widely accepted as the most appropriate and useful measure for defining overweight and obesity in children and adolescents. However, in practice of prevention, control, and intervention of childhood obesity, BMI has some limitations. For the index itself, it fails to assess the accumulation of abdominal fat, which mainly increases the risk of diabetes, hypertension, and cardiovascular diseases. Moreover, BMI cut-off points for age and gender may be appropriate for professionals, but it is too complicated for self-assessment and monitoring for children or their parents. Previous studies suggested that different BMI cut-off points should be established among race/ethnic populations for a better sensitivity and specificity.

Waist to Height Ratio

Waist to Height Ratio has several advantages over BMI in practice for identifying overweight and obese children in a population. In addition, WHTR, as a diagnostic test, was shown as having higher accuracy than waist circumference. WHTR is a simple, easy, inexpensive, and accurate index for identifying overweight and obesity in children and adolescents (Yan *et al*., 2007). The ratio of the waist circumference to height (WHTR) was proposed almost simultaneously in Japan (Hsieh and Yoshinaga 1995a, b) and UK (Ashwell *et al*., 1996; Cox *et al*. 1996), as a way of assessing shape and monitoring risk reduction. Both research groups suggested that WHTR values above 0.5 should indicate increased risk. The UK group also suggested that values above 0.6 indicate substantially increased risk (Ashwell, 1997). Since then, studies in Taiwan have also demonstrated the superiority of WHTR over other anthropometric indices for the prediction of metabolic risks (Lyu *et al*., 2003; Lin *et al*., 2002).

Further research in other populations to determine optimal boundary values for WHTR has indicated that WHTR=0.5 is the simplest value that corresponds to more precise boundary values in both sexes (Bertsias *et al*., 2003; Lin *et al*., 2002). The threshold of 0.5 for waist height ratio is recommended by McCarthy *et al*. (2006). Prospective studies (Cox and Whichelow, 1996) showed that both waist circumference and WHTR are better than BMI at predicting CHD deaths and all-cause mortality. WHTR is a slightly better predictor than waist circumference alone. This is probably because there is a positive association between waist and height in global populations of mixed ethnicity which include a wide range of heights. It is also possible that the independent negative association between height and mortality contributes to the predictive powers of WHTR.

One advantage of using WHTR over waist circumference in a public health context is that boundary values can be set which are the same for men and women. A second advantage of these suggested boundary values, which have been derived from UK (Ashwell *et al*., 1996), Japanese (Hsieh and Yoshinaga, 1995b) and Chinese (Ho *et al*., 2003) populations completely independently, is that the estimated size (but not the members) of the population at risk is similar to that estimated by BMI. Furthermore, the proportion of men at risk using WHTR is greater than the proportion of women at risk, reflecting the greater propensity for men to store visceral fat. An exciting thought for the future is that WHTR may allow the same boundary value for children and adults. There is now growing evidence that WHTR can be used to predict risk in children (Kahn *et al*., 2005; Savva *et al*., 2000; Hara *et al*., 2002). Since the height and waist circumference of children increases continually as they age, the same boundary value (WHTR=0.5) could be used to indicate increased risk across all age groups (McCarthy and Ashwell, 2003, 2002). Waist to Height Ratio (WHTR) has the potential to be globally applicable to different ethnic populations and to children as well as adults. Further validation, particularly of the suggested boundary values of 0.5 and 0.6, as used within the Ashwell Shape Chart to indicate different levels of risk, is required (Ashwell and Hsieh, 2005).

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An exciting thought for the future is that WHTR may allow the same boundary value for children and adults. There is now growing evidence that WHTR can be used to predict risk in children. Since the height and waist circumference of children increases continually as they age, the same boundary value (WHTR=0.5) could be used to indicate increased risk across all age groups (Ashwell *et al*., 1996). No research to date has performed analyses to determine the appropriate cut-offs for WC when stratified by BMI category, but if the combined screening of increased health risk by WC and BMI is to be recommended, this should be a priority for future research (Ardern *et al*., 2003).

Most studies use BMI when evaluating the health effect and mortality associated with obesity (Visscher *et al*., 2000; Seidell *et al*., 1996; Manson *et al*., 1995). BMI predicted non-abdominal fat and abdominal subcutaneous fat, whereas waist circumference predicted the visceral fat, thus reinforcing the use of both BMI and waist circumference in clinical practice (Janssen *et al*., 2002a). Although waist circumference and BMI are highly correlated, they seem to measure different aspects of obesity. For given values of BMI, waist circumference probably reflects abdominal fat deposits; and for given waist circumference, BMI probably reflects not only fat-free mass, but also, in particular, fat deposits elsewhere in the obese BMI range. It is more complicated to evaluate BMI or relative weight among children and adolescents because increases in weight and height are part of development; thus, one must have information on age to interpret BMI. Moreover, due to gender differences in body fatness, timing of puberty, height change, and height velocity, it is essential to interpret BMI in the context of age and gender (Taylor *et al*., 1998).

Waist to Hip Ratio

Relative fat distribution can be measured by the ratio of waist circumference to hip circumference (WHR). This was shown to be a good predictor of health risk and was popular for many years. However, although very useful for risk assessment, WHR is not helpful in a risk management in a public health context because both waist and hip can decrease with weight reduction and so the ratio of WHR changes very little. So, attention then shifted to the use of waist circumference alone as a possible replacement for BMI (Despre's, 2001). A larger waist hip ratio in adults indicates relatively larger amounts of abdominal fat and has been used to describe body fat distribution. However it is influenced by several other bodily factors and there is some evidence that it is a poorer measure of body fat distribution in children (Sweeting, 2007). Despre's (2001) produced exciting results from the Quebec Cardiovascular Study which show that waist circumference alone is much better than BMI for predicting not only the traditional metabolic complications of excess fat (hypertension, CVD and NIDDM) but also the newer very important risk factors or 'markers' for these complications (high insulin, high Apoprotein B, increased concentration of small dense lipoprotein particles; glucose intolerance, high triglycerides, low HDL cholesterol, high cholesterol to HDL ratio, insulin resistance and altered haemostatic variables).

Skinfold Thickness

Combining skinfold thickness with circumference and/or bone breadth measures provide a more precise prediction of percent body fat in comparison with established SF equations (Garcia *et al*., 2005). Predictive equations derived from skin-fold thickness (WHO, 2000) measurements provide good associations with body fat mass (BFM) estimation compared with the reference methods (Fogelholm and Lichtenbelt, 1997). Additionally, skin fold measurements are preferred in clinical or epidemiological settings because of lower costs and less methodological effort. As a result, a broad variety of predictive equations using skin fold measurements alone or in combination with other anthropometric measurements (circumference, length and breadth) have been developed (Wang *et al*., 2000; Heyward, 1996).

2. 5. 2. *Hospital Based Methods*

Several techniques have been used to assess percent body fat in controlled laboratory conditions. These include underwater weighing (densitometry), dual energy X-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA) and magnetic resonance imaging (MRI). However, densitometry, DEXA, and MRI are expensive, inconvenient for the participant, and not feasible to conduct in the field because they require large specialized equipment. For these reasons, their use in large epidemiological studies is limited. BIA, by contrast, is relatively simple, quick and non-invasive which gives reliable measurements of body composition with minimal intra- and inter-observer variability the results are available immediately and reproducible with <1 per cent error on repeated measurement (Segal *et al*., 1991). This technique became commercially available for the first time in the mid 1980s (Buchholz *et al*., 2004), and requires inexpensive, portable equipment, making it an appealing alternative to assess body composition in epidemiological studies (Azinge *et al*., 2003).

Many empirical equations have been developed for estimation of total body weight (TBW), fat free mass (FFM) and body cell mass (BCM), by using sex, age, weight, height and race as explanatory variables. However, predictive equations are generally population-specific and can be useful only for those populations with characteristics similar to those of the reference populations (Kyle *et al*., 2003; Deurenberg *et al*., 2002b). When these equations have been used to predict body composition in different populations, the results have been inconsistent. The developed predictive equations cannot be generalized to diverse populations. While reviewing the reliability and validity of different equations for African Americans, Asians and Indian Americans, Heyward and Wagner, (2004) found that the majority of studies indicated that the BIA method is not accurate when a generalized equation is applied for different ethnic groups.

Vague (1956) first pointed out in the 1940s and 50s the people with a 'central' type of fat distribution (android shape) were at greater health risk than those whose fat was deposited 'peripherally' (gynoid shape). However, it has only been in the last decade that there has been a consensus view that health risks (predominantly CVD and diabetes) can be determined as much by the relative distribution of the excess fat as by its total amount. Only very recently has there been any media interest in the 'unhealthy apple shape' and the 'healthy pear shape'. The use of imaging techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) have subsequently indicated that the 'unhealthy apple shape' is associated with a preferential deposition of fat in the internal, visceral fat depots rather than the external, subcutaneous fat depots (Buchholz *et al*., 2004).

3. MATERIALS AND METHODS

The study on “Multiple correlates of obesity among school children” was carried out to determine the incidence of obesity and the major contributing factors of obesity among school children aged 7 to 12 years. The methodology of the present research comprised of the following steps.

3.1 Selection of the study area

3.2 Selection of the sample

3.3 Selection of techniques and tools for data collection

3.3.1 Obesity screening

3.3.2 Socio-economic background and life style of the sample

3.3.3 Dietary assessment – Dietary habits and food consumption pattern (24 hr recall survey)

3.3.4 Clinical status

3.3.5 Biochemical profile

- Serum lipid profile
- Blood haemoglobin level

3.4 Data Analysis

3.1. Selection of the study area

The study was conducted in Thrissur district, the cultural capital of Kerala which is centrally located in the State of Kerala. The district is being urbanized faster, due to industrialization and subsequent modernisation. Improved air, rail and road connectivity, cultural heritage and rising trend in tourism industry, changing trend in life style and consumerist behaviour all these give an impetus to the rapid urbanization, which is an independent risk factor of obesity. Moreover scarcity of data base from this area on the topic also factored in the selection of Thrissur as the area of study. Location map of Thrissur, Kerala, the study area is given in Figure 3.1.

3.2. Selection of the sample

Multi-stage random sampling (Panse and Sukhatme, 1978) was the technique adopted for sample selection. Various schools (Government, private aided and unaided) in Thrissur district (Appendix I) were the first stage units. Since the age group of the subjects in the present research, ranged between 7 to 12 years, only LP and UP schools in Thrissur District were taken into account during sample selection. Out of 749 LP and UP schools (Anonymous, 2005) seven schools were identified based on random selection with proportionate number from the three geographical locations (Corporation, Municipality and Panchayath areas) and the three types of school administration like Government, private aided and unaided. Availability of the sample and willingness of the school authorities to co-operate with the study were also the essential criteria for selection of schools for the study.

The second stage consisted of the selection of subjects, the school children, between the age group of 7 to 12 years. The age group of 7 to 9 years was included in the study for medical and practical reasons because at this age, children are at pre-pubertal stage (puberty would induce a significant variation in fat content between genders), and overweight in this age group is of value for predicting obesity (Serdula *et al*., 1993). To know the “pure prevalence” in children it is better to choose an age

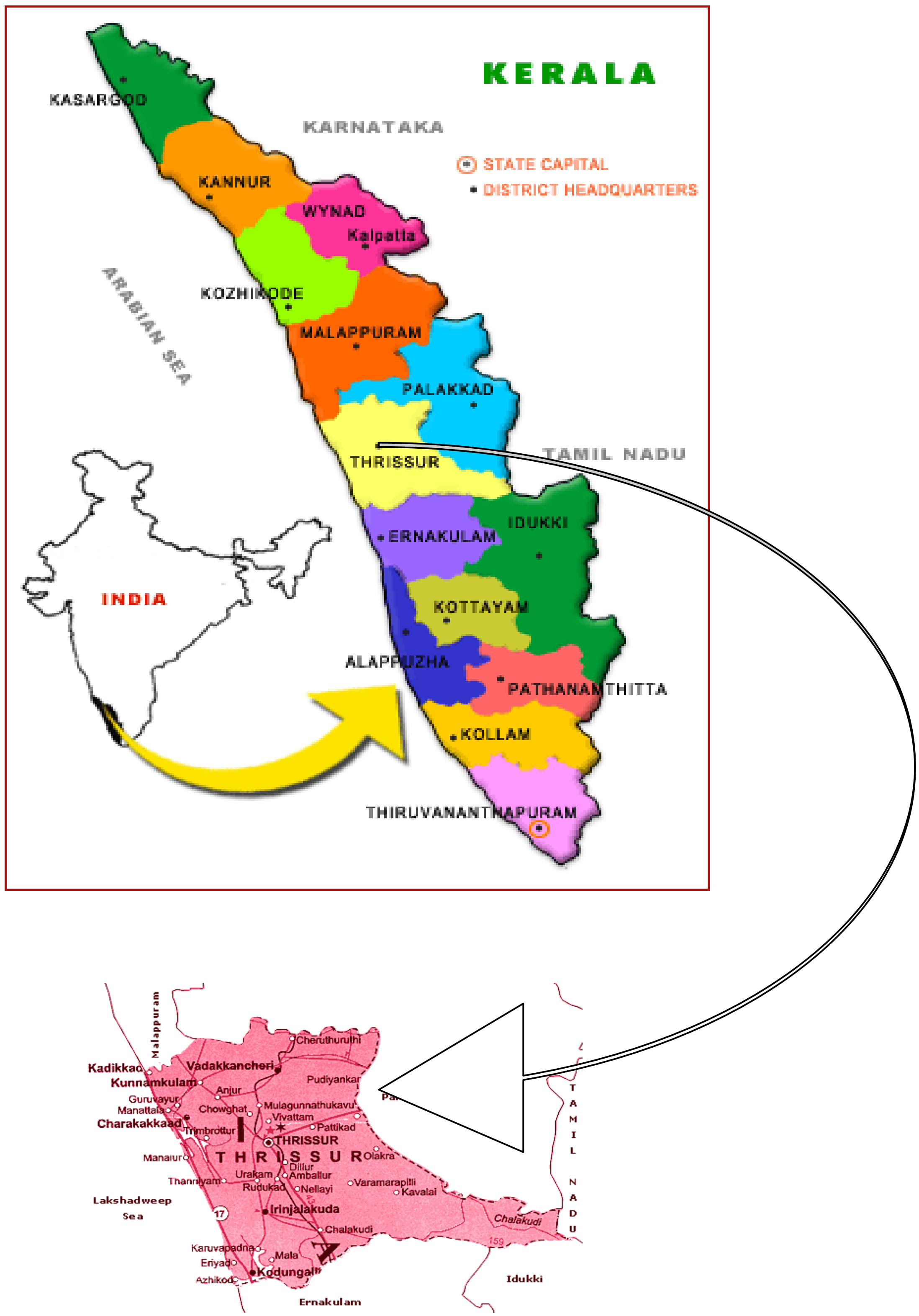

Figure 3. 1. Location map of Thrissur, Kerala

when obesity development is quite low, such as between 7 and 9 years (Lehingue, 1999). At these ages the adiposity rebound and puberty sets in, which are two moments when the development of new cases of obesity are more frequent, have already happened and not yet started, respectively. Furthermore, if the prevalence information is to be used to start preventive interventions, the young childhood age range of 7 to 12 years should be chosen, in order to obtain data not only on the prevalence of excess body weight, but also on its development factors, and to intervene before obesity is stably established (O'Brien *et al.*, 2004; US Preventive Services Task Force 2005; McCallum and Gerner, 2005).

In the second stage, 3000 school going children (7 – 12 years) were included in the sample. The number of children selected from each school was in proportion to the total number of children in the school. The schematic diagram on the procedure followed in the selection of sample for the study is presented in Figure 3.2.

3. 3. Selection of techniques and tools for data collection

3.3.1. Obesity screening

Tools and techniques used for the collection of research data should be appropriate and accurate for ensuring credibility of information.

For obesity screening the investigator approached the school authorities and obtained their permission for the conduct of the study. The school children were also made aware of the project and their cooperation in the successful completion of the study. The date and time of the survey was also fixed and communicated to them well in advance.

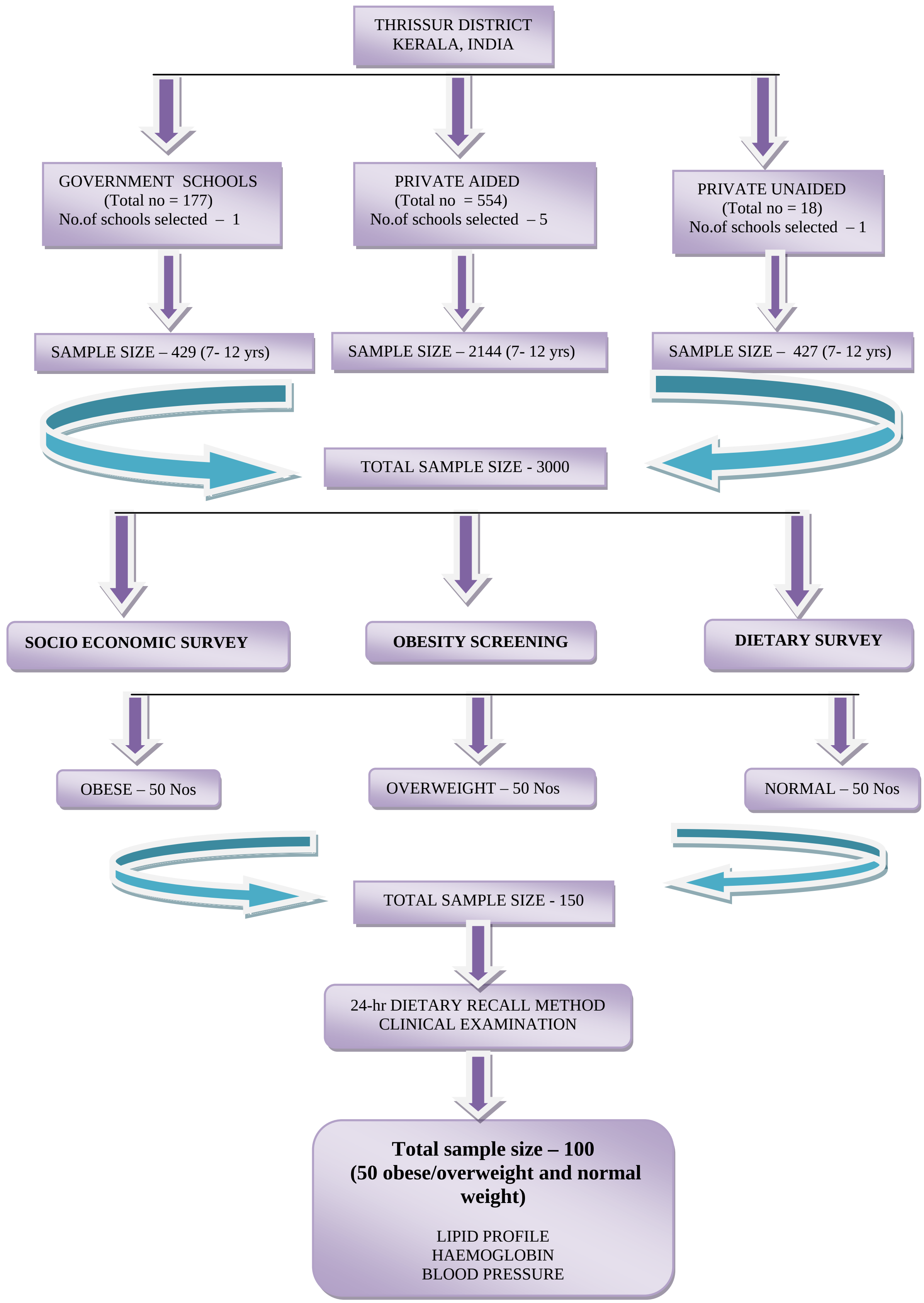

Figure 3. 2. Research design followed in this study

The anthropometric survey for screening obesity among the sample was conducted by the investigator on a population of 3000 school going children of 7 to 12 years. The physical measurements like body weight, height, MUAC, skinfold thickness, waist and hip circumferences were used to assess the extent of prevalence of obesity/overweight among the sample (school children).

Weight and height are easy to measure, but the anthropometric indices derived from these measures are often considered more useful than the measures alone (WHO, 1995). During childhood and adolescence the ratio between height and weight varies with sex and age. Weight is dependent on height, thus, in choosing a ratio to define obesity, attention has to be paid to choosing the ratio where height shows the least influence on weight (Franklin, 1999). Although commonly used, BMI does not give an indication of the distribution of fat. Waist circumference can be a good indicator of the amount of abdominal fat. The measurement of abdominal fat is important, since an excess of abdominal fat (independently of total body fat) is associated with metabolic abnormalities, such as hyperinsulinemia and dyslipidemia (Freedman *et al.,* 1999). In addition, a high waist circumference in childhood tracks well into adulthood (Goran *et al*., 1998).

Hip measurements provide additional valuable information related to gluteofemural muscle mass and bone structure (WHO, 2000). The waist/hip ratio may be a useful measure, since it also includes accumulation of fat on the hips, which may be of beneficial value for health (Seidell *et al*., 2001). As a result, the measurement of waist and hip circumference, singularly or reciprocally associated in different ratios, has been proposed as a simple and reliable method to diagnose excess body weight and mostly cardiovascular risk (Higgins *et al*., 2001; Maffeis *et al*., 2001; Taylor *et al*., 2000).

The measurement of triceps, biceps, subscapular, and superiliac skinfold thickness directly measures subcutaneous fat and indirectly the total fat mass. (Wells, 2001).

Considering the above facts, the anthropometric survey was conducted with the help of a schedule in which height, weight, BMI, MUAC (Mid Upper Arm Circumference), waist circumference, hip circumference, fat fold at triceps, biceps, sub scapular and abdomen of 3000 school children in the age group of 7 to 12 years have been recorded. Copy of the schedule is given in Appendix II. The aim of this survey was to identify obese, overweight and normal children and to determine the prevalence of obesity and weight abnormalities among school going children. The anthropometric measurements were taken using suitable standardized procedures. The details are given below.

Body Weight

Body weight is the most widely used sensitive and simplest reproducible anthropometric measurement. It indicates the body mass and is a composite of all body constituents like water, mineral, fat, protein and bone. It reflects more recent nutrition (Srilakshmi, 2004). Body weight of children was recorded using a bathroom balance, which was checked by calibration with standard weights as directed by Jelliffe and Jelliffe (1991). The students were asked to stand upright, bare footed on the weighing machine looking straight, while the measurement was read. The weight was recorded to the nearest 0.25 kg. Each reading was taken thrice and the average was taken as the final measurement.

Height

The height of children was measured using a stadiometer. The subject was made to stand erect looking straight on the platform of stadiometer with heels together and toes apart, without shoes. Height was read to the nearest of 0.5 cm. An average of three measurements was taken as the final measurement (Jelliffe and Jelliffe, 1991).

Age was recorded in completed years of life and rounded to the nearest year. Nutritional status was assessed using weight for age classification (Gomez *et al*., 1956), and comparing the mean heights and weights of each age group with the standard measurements of National Centre for Health Statistics (ICMR, 1990). Height for age classification (Waterlow, 1972) was compared with the standards by National Centre for Health Statistics (ICMR, 1990). All the standard measurements of height and weight used for comparison are given in Appendix – III

Body Mass Index and Percentiles

Obesity classification based on BMI

Obesity is a state of excess adipose tissue mass. Although often viewed as equivalent to increased body weight, this need not be the case, lean but very muscular individuals may be overweight by arbitrary standards without having increased adiposity. Although not a direct measure of adiposity the most widely used method to gauge obesity is the Body Mass Index (Kapil, 2004). Body Mass Index in childhood changes substantially with age (Cachera *et al*., 1982), so cut- off point related to age is needed to define child obesity (Power *et al*., 1997). The adult cut off points in widest use are body mass index of 25 kg/m^2 for overweight and 30 kg/m^2 for obesity (WHO, 1995).

Body Mass Index of 3000 school children (7-12 years) was computed using the equation, BMI = Weight in kgs/ Height in m^2 and compared with the nutritional status classification (Appendix - IV) given by James *et al*., (1988).

Obesity classification based on BMI percentiles

According to International Obesity Task Force (IOTF) adult cut-off points has been linked with Body Mass Index centiles for children to provide child cut-off points (Bellizi and Dietz, 1999). Obesity classification based on BMI percentile has been given by CDC (2009), Khadilkar *et al*., (2007) and also by Cole *et al*., (2000).

The BMI of the sample (n = 3000) computed was compared with the percentile values given by Cole *et al*., (2000) and incidence of obesity and overweight among the study population was arrived. The international cut-off points of BMI for school children suggested by (Cole *et al*., 2000) is given in Appendix – IV.

Centres for Disease Control and Prevention (CDC, 2009) of United States has also formulated the obesity and overweight percentile values for school going children based on sex, age, weight and height (Appendix –IV). This tool for CDC percentile calculation is freely available at http://apps.nccd.cdc.gov/dnpabmi/Result.aspx and in the present study; the CDC percentile values for the sample population were calculated online using this service.

Thirdly since the above system consider population outside India, the percentile values formulated exclusively for school going children in India by Indian Academy of Paediatrics (Khadilkar *et al*., 2007) was also used as standard for comparison to identify obese and overweight children among the sample studied. The BMI cut-off points for Indian children are given in Appendix-IV.

Obesity classification based on waist circumference percentiles

Waist circumference, on all the 3000 school children was measured, midway between the lower rib margin and the iliac crest, with a plastic tape to the nearest 0.1 cm. A non-elastic flexible tape measure was employed with the subject in the standing position (WHO, 1995; BSI, 1990).

The centile values for obesity and overweight of children based on the waist circumference given by McCarthy *et al*., (2001) were used in the present study to identify obese and overweight subjects. The reference values given by McCarthy *et al*., (2001) are shown in Appendix – V.

Obesity classification based on Waist to Height ratio

Waist to height ratio is a simple and effective global indicator for health risks (Hara *et al*. 2002; Kahn *et al*., 2005). Since the height and waist circumferences of children increase continually with the age, the boundary value of 0.5 could be used across all age groups (Ashwell and Hsieh, 2005; McCarthy and Ashwell, 2003). So waist to height ratio of all samples was computed to find out the extent of prevalence of under/over nutrition.

Mid Upper Arm Circumference (MUAC)

Muscles and fat constitute the soft tissues that vary with a deficiency of proteins and calories. Measurement of the mid upper arm circumference is the most useful practical method for assessing muscle mass, as this region is easily assessable. MUAC of all subjects (n=3000) was measured using the standard procedure (Gopaldas and Seshadri, 1987). The child was asked to flex his left arm at the elbow such that the lower arm is at right angle to the upper arm. The length between the acromion process of the scapula and olecranon process of the ulna was measured with a flexible tape and the site of measurement, exactly midway down the upper arm, was marked with a pen. The child was then asked to hang the arms relaxed by the side and the tape was passed gently but firmly around the midpoint to avoid compression of the tissues of the arm. Each measurement was made twice to ensure accuracy and recorded to the nearest 0.1 cm.

Hip Circumference

Hip circumference (to the nearest 0.1 cm) was measured at the level of the greater trochanter (Jelliffe and Jelliffe, 1991) on the entire sample (n=3000).

Waist to hip ratio

Waist to hip ratio of the subjects was calculated using the formula given below

$$\text{Waist to Hip ratio} = \frac{\text{Waist circumference (cm)}}{\text{Hip circumference (cm)}}$$

Waist to hip ratio is important in determining obesity. The ratio above the cut-off values has been accepted as a method to identify abdominal fat accumulation

(Vijayalakshmi *et al*., 2003). Waist to hip ratio of school children (n=3000) were calculated from waist and hip circumference values.

Skin fold thickness, Body fat percentage and Lean body mass

Skin fold thickness of 3000 sample of 7 to 12 years was measured at triceps, biceps, sub scapula and abdomen using Harpenden skinfold calipers and was recorded to the nearest accuracy of 0.1mm. From the measured skinfold values, body density, body fat percentage and lean body mass were calculated. The techniques adopted for the measurement of skin fold thickness at various sites are described below:

Fat fold at triceps

Fat fold at triceps was measured using Harpenden skinfold calipers by picking a vertical fold on the posterior midline of the upper arm over the triceps muscle, half way between the acromion process (bony process on the top of the shoulder) and the olecranon process (bony process on elbow).The elbows were extended and in the relaxed state. (Deurenberg *et al*., 1989).

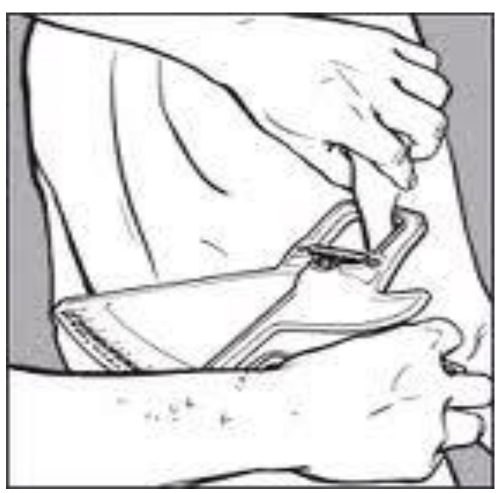

Figure 3. 3. Location for triceps skinfold

Fat fold at biceps

Measurement was taken at the anterior surface of the biceps between the anterior auxiliary fold and the antecubital fossa. (Deurenberg *et al*., 1989).

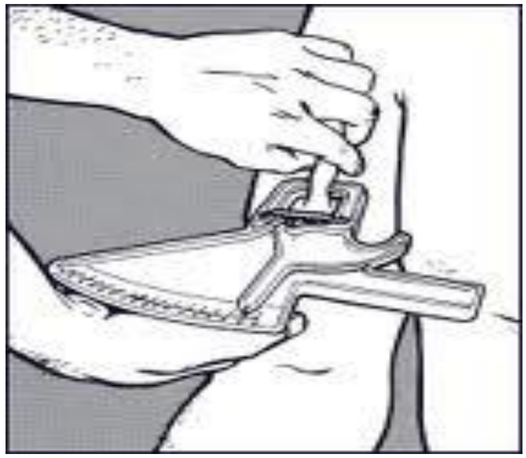

Figure 3. 4. Location for biceps skinfold

Fat fold at sub scapula

The fold was taken on the diagonal line coming from the vertebral border to between 1 and 2 cm from the inferior angle of the scapulae (A diagonal fold about 1 to 2 cm below the point of the shoulder blade and 1 to 2 cm toward the arm) (Deurenberg *et al*., 1989).

Figure 3. 5. Location for sub scapular skinfold

Fat fold at abdomen

It was measured by taking a vertical fold at the lateral distance of approximately 2 cm from the umbilicus (2 cm to the side of the umbilicus) (Deurenberg *et al*., 1989).

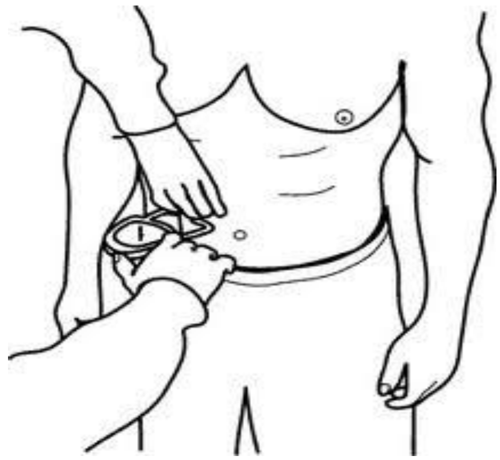

Figure 3. 6. Location for abdomen skinfold

Body Density

Body density was determined using the equation (Ardle *et al*., 1986) given below:

Body Density = 1.09665- (0.00103 X_1) – (0.00056 X_2) - (0.00054 X_3) where X_1 = Triceps skinfold, X_2 = Subscapular skinfold, X_3 = Abdominal skinfold

This was computed for the entire sample (n=3000) in the study.

Body Fat Percentage

Percentage of body fat was determined by the equation given by Siri (1956)

Body fat percentage = (4.57/Body density-4.142) x 100

An easy method of assessing the percentage body fat in children as given by Forbes (1987) is the measurement of subcutaneous fat layer, *i.e.* skin fold thickness. These thickness measurements do not measure overall body fat mass or its percentage directly but rely on validated equations that describe the relationship between measures of skin fold fat as well as other body dimensions and the measured body density. Prediction of body density and percentage body fat from skin fold thicknesses is an acceptable method for the assessment of body composition in childhood and adolescence (Deurenberg *et al.* 1989).

The body fat percentage was found out for the entire sample included in the study.

Lean Body Mass

Lean Body Mass was determined using the equation given by Ardle *et al*. (1986).

LBM = Body weight (kg) - [(Body fat percentage/100) x Body weight]

The samples were analysed using this methodology.

3.3.2. Socio-economic background and life style of the sample

From the data on socio economic background and life style, valuable information to identify the risk factors of obesity was collected by interview method. The interview method involved presentation of oral verbal stimuli and reply in terms of oral verbal responses.

The chief merits of interview method are that it is a much more flexible method and provides more information and that too in greater depth (Kothari, 2005). According to Gupta *et al*., (2003), interview facilitates inter-stimulation between the interviewer and interviewee and helps to secure data, not obtainable by methods that do not involve any interpersonal relationship. Interview method is suitable way to collect the data as it proceeds systematically and enables to record the information quickly (Kothari, 2001). The information obtained by this method is likely to be more accurate because the interviewer can clear up doubts of informants and thus obtain correct information (Singh, 1997). The interview method can be made to yield an almost perfect sample of the general population, and the information secured is likely to be more correct compared to that secured through other techniques. The information received is more reliable as the accuracy could be checked by supplementary questions (Carter *et al.*, 1987). Therefore in the present study the direct interview method was adopted to procure the related information with the help of an interview schedule.

The interview schedule was intended to collect data on family background, socioeconomic profile, housing conditions and also the life style and morbidity pattern of the school children. The pretested schedule is given in Appendix – VI. The interview schedule was administered among the mothers of 3000 school children aged between 7 to 12 years.

3.3.3 Dietary assessment

Dietary habits

Diet surveys constitute an essential part of any complete study of nutritional status of individuals or groups providing essential information on nutrient intake levels, sources of nutrients, food habits and attitudes (Swaminathan, 2004). According to Thimmayamma and Rao, (1996) diet is a vital determinant of health and nutritional status. Dietary factors are considered to be a major risk factor in the development of obesity especially among children (Merchant *et al.*, 2007).

Diet surveys are mainly of two types, one which concentrates on qualitative aspects of the foods, i.e. what kinds of foods are eaten, and the other which attempts to estimate the amounts of foods consumed in quantitative terms, i.e. how much of food is eaten. Both this types were included in this study to elicit information regarding dietary habits and food and nutrient intake of school children.

Dietary survey was conducted among the mothers of 3000 school children of the age group 7 to 12 years who formed the study population. A separate schedule was developed to gather information regarding the food habits, dietary practices of the families, food expenditure pattern and frequency of use of various foods. Use of fast foods and ready-to-eat foods of the selected sample was also recorded. The pretested schedule used for the survey is presented in Appendix-VII.

Food consumption pattern

Twenty four hour dietary recall was conducted on a sub sample of 150 school going children, including 50 each respectively from obese, overweight and normal weight children selected based on CDC percentiles.

Twenty four hour dietary recall on a large group of participants is an efficient way to measure the average dietary intake of a group (Patterson and Pietinen, 2004; Willet *et al*., 1998; Thimmayamma, 1987). According to Garrow (2000) in diet recall, the respondent is asked to recall the actual food and drink consumed on specific days, usually the immediate past 24 hours (24 hour recall).

During the interview, food models and reference standard measuring cups and spoons were shown to the subjects so that they could give the portion sizes accurately. Food items available in natural units (eg. A slice of bread, one egg, one fruit) add clarity to the question (Singha *et al*., 1998). Values of household measures, eg. Cups, spoons were converted into raw equivalents and the nutrient intake was calculated using the food composition table. The mean food and nutrient intake of the sample was also computed and compared with RDA given by ICMR, (1998) and ICMR, (2009) respectively. The schedule used is given in Appendix –VIII

3.3.4 Clinical status

Clinical assessment is an important and sound method of assessing the nutritional status of a community. It gives direct information on signs and symptoms of dietary deficiencies (Kamath, 1986).

Clinical examination, on a sub sample of 150 children selected based on CDC percentiles through purposive sampling (50 each respectively from obese, over weight and normal weight children) was conducted with the help of a qualified physician. The schedule used for clinical examination is given in Appendix – IX.

Blood Pressure

Children from the representative sample comprising 100 children (50 each respectively from obese/overweight and normal weight children) were called for screening and were given rest for 5 minutes. The procedure were explained briefly and demonstrated to them. The BP was measured using a standardized mercury sphygmomanometer and recorded by trained paramedical personnel. BP was measured in a sitting posture with the hands resting on the examining table with the cubital fossa supported at the level of the heart. The stethoscope was placed over the brachial artery pulse, proximal and medial to the cubital fossa and below the bottom edge of the cuff (i.e. about 2 cm above the cubital fossa). Cuffs having a bladder width approximately 40% of the arm circumference midway between the olecranon and acromion were used. The BP measurement was done on the right arm for consistency. Three readings of the BP of each child were taken, maintaining an interval of 2 minutes between readings. The mean of three readings was reported.

3.3.5 Biochemical profile

Biochemical parameters which can be tested on easily accessible body fluids such as blood and urine, can help to diagnose disease at the sub clinical stage, and confirm clinical diagnosis at the disease stage (Bamji, 2003). Biochemical profile with respect to blood lipids and blood haemoglobin were assessed and recorded and the schedule used is given along with Appendix – X.

Serum Lipid profile

Varley, (1988) has shown a clean and consistent association between obesity and abnormalities in lipoprotein fractions. These include both increase in VLDL and reduction in HDL.

The serum lipid profile is used in determining the amount of different lipids in blood in order to assess the risk levels of obesity. Lipid profile of selected sub sample of 100 children (50 each respectively from obese/over weight and normal weight children) was tested.

The following lipid fractions were estimated on the sub sample of 100 children (50 each respectively from obese/ overweight and normal weight children).

- Estimation of serum cholesterol CHOD-PAP method suggested by Allian (1995).
- Estimation of triglycerides GPO-PAP method Werner *et al*., (1981).
- Estimation of HDL (NCEP, 2002).

The procedures are given in Appendix – XI

High HDL cholesterol is considered to be good cholesterol with protective effect on CVD and a low HDL is considered to be a positive risk factor for CVD.

LDL were computed using the Friedewald formulae (Friedewald *et al*., 1972):

LDL cholesterol = (Total Cholesterol) – (HDL cholesterol) x $\left(\frac{\text{Triglycerides}}{5}\right)$

VLDL= $\left(\frac{\text{Triglycerides}}{5}\right)$

The estimated values were compared with the normal values suggested by NCEP (2002).

Blood Haemoglobin

Estimation of blood haemoglobin was also carried out on a subsample of 100 children (50 each respectively from obese/overweight and normal weight children) to study the prevalence of anaemia. This estimation was done using Cyanmethaemoglobin method suggested by National Institute of Nutrition, India (NIN, 1983). The procedure is given in – XI. The mean Hb values were computed and compared with the referece values given by (NIN, 1983).

3. 4. Data Analysis

The data collected were analyzed using suitable statistical procedures like correlation, path analysis, multiple regressions, classification tools such as cluster analysis and factor analysis with SPSS version 12 and Minitab version 5. The details of statistical procedures are given in Appendix XII.

4. RESULTS AND DISCUSSION

The results pertaining to the study 'Multiple Correlates of Obesity among School Children' and the discussion in relation to the current understanding are detailed under the following heads.

4. 1. Obesity screening

4. 1. 1. Weight and Height measurements

4. 1. 2. Body Mass Index

4. 1. 3. Waist and Hip circumferences / Ratio

4. 1. 4. Mid upper arm circumference (MUAC)

4. 1. 5. Skinfold thickness

4. 1. 6. Body density, body fat percentage and lean body mass

4. 2. General background

4. 2. 1. Socio-economic conditions

4. 2. 2. Personal profile of the sample

4. 3. Dietary Practices

4. 3. 1. Food habits and meal pattern

4. 3. 2. Food expenditure pattern

4. 3. 3. Frequency of consumption of foods

4. 3. 4. Eating behaviour of school going children

4. 3. 5. Food consumption pattern of the sample

4. 4. Clinical picture

4. 5. Bio-chemical parameters

4. 5. 1. Blood lipid profile

4. 5. 2. Blood haemoglobin content and Blood pressure levels of the sample

4. 5. 3. Bivariate correlation between biochemical parameters and obesity

4. 5. 4. Correlation between blood lipid and BMI of the sample

4. 5. 5. Correlation between blood pressure and BMI of the sample

4. 5. 6. Formulation of a predictive index for overweight/obesity based on the biochemical parameters

4. 6. Multiple correlates of obesity among school children

4. 6. 1. Correlation of BMI with *Physical body parameters*

4. 6. 2. Correlation of BMI with *Body composition parameters*

4. 6. 3. Correlation of BMI with *Birth and Family Related parameters*

4. 6. 4. Correlation of BMI with *Food habits and life style related parameters*

4. 7. Prediction Index for childhood obesity

4. 7. 1. Factor analysis of principal components

4. 7. 2. Prediction Index

4. 1. Obesity screening

4. 1. 1. Weight and Height measurements

The mean weight and height of children belonging to different age groups were compared with the NCHS standards and the results are furnished in the Table 4.1, and Figures 4.1. and 4.2.

Table 4. 1. Mean height and weight of school children in comparison with NCHS standards

Age	Height (cm)		Weight (kg)	
	Boys	**Girls**	**Boys**	**Girls**
7 years				
Mean	124.63±9.66	117.7±7.10	23.06±5.76	19.54±4.14
Standard	121.70	120.6	22.90	21.80
t value	2.139*	2.843**	0.197^{NS}	3.779**
8 years				
Mean	130.00±6.98	129.00±6.44	26.05±8.19	23.86±4.91
Standard	127.00	126.40	25.30	24.80
t value	2.586**	3.095**	0.549^{NS}	1.471^{NS}
9 years				
Mean	134.00±6.22	131.00±6.74	26.93±6.19	27.43±7.92
Standard	132.20	132.20	28.10	28.50
t value	2.005*	1.622^{NS}	1.310^{NS}	0.817^{NS}
10 years				
Mean	138.00±7.51	136.00±7.33	28.60±7.11	30.43±7.51
Standard	137.50	138.30	32.50	31.40
t value	0.258^{NS}	1.83^{NS}	2.123^{NS}	1.329^{NS}
11 years				
Mean	142.00±8.5	139.00±7.78	30.04±5.59	31.32±7.19
Standard	143.30	144.80	35.30	37.00
t value	0.802^{NS}	4.833**	4.974**	5.518**

12 years				
Mean	146.18±7.80	143.54±7.21	32.79±7.10	32.96±5.61
Standard	149.70	151.50	39.80	41.50
t value	3.504**	5.714**	7.711**	7.764**

Ref: ICMR (1990)

** Significant at 1 per cent level, * significant at 5 per cent level, NS Not significant

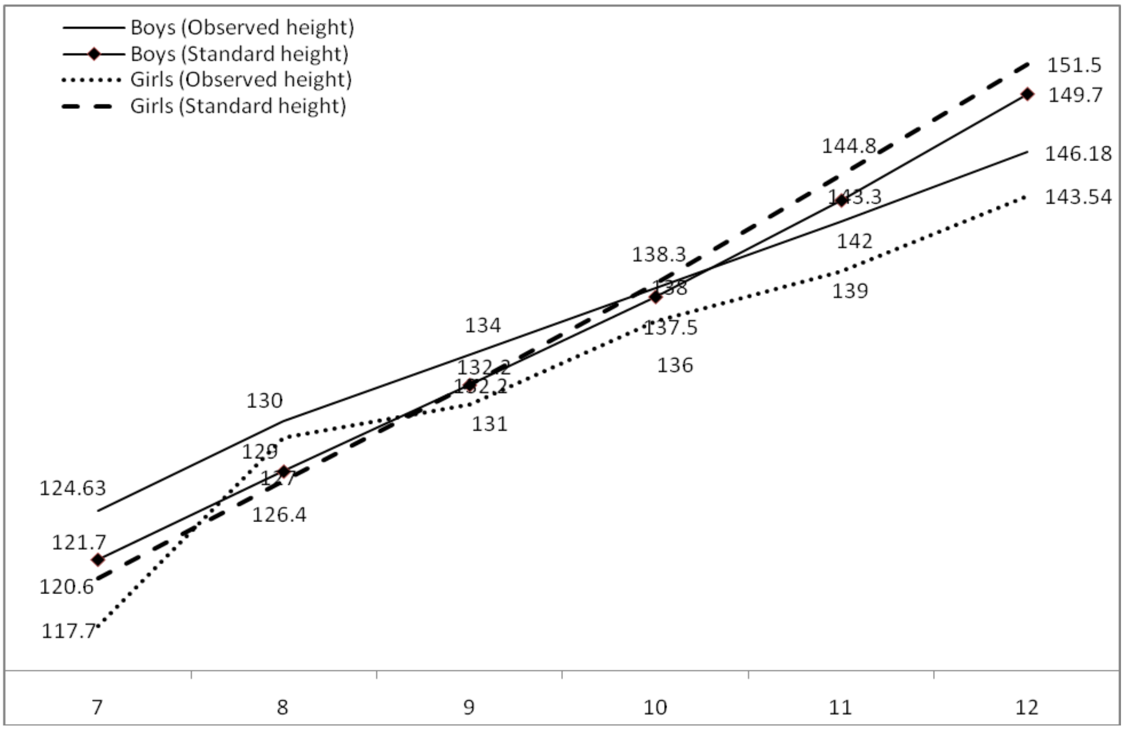

Figure 4. 1. Mean heights of school children in comparison with NCHS standards

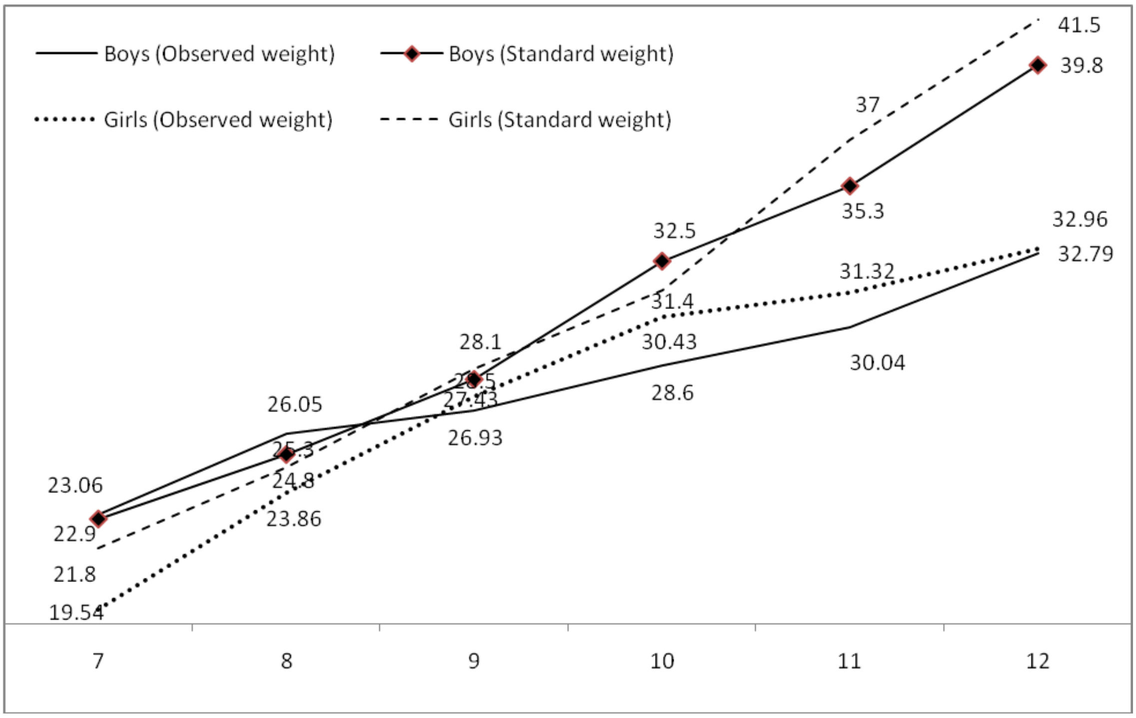

Figure 4. 2. Mean weights of school children in comparison with NCHS standards

There observed a progressive increase in the mean heights and weights of the sample (both boys and girls) in all age groups (7 – 12 years). The observed mean heights were significantly higher than the NCHS standards in case of boys between 7 to 10 years of age. But after that the observed values were less than the standard values, which was found to be highly significant (at 1 per cent level) in the 12 year age group. But for girls, the observed mean heights were invariably lower than the NCHS standards except for 8 year old girls. The positive deviation for mean height except for 9 and 10 year old girls, including 8 year old also was highly significant at 1 per cent level.

Mean weights of both boys and girls were less than the standard weights for the age recommended by NCHS, although the difference observed was insignificant in most of the age groups, except 11 and 12 years, where the deficit was found to be significant at 1 per cent level. Boys in general were taller and lighter than girls.

Weight for Age Classification

Weight for age classification (Gomez *et al*., 1956) generally used for assessing the degree of malnutrition among children, was employed to assess the nutritional status of school children. The results are given in the Table 4. 2.

Table 4. 2. Distribution of school children based on weight for age classification

Age	Weight for age classification				Total
	≤60 Grade III Malnutrition	**60–75 Grade II Malnutrition**	**75–90 Grade I Malnutrition**	**>90 Normal**	
7 years					
Boys	0	25 (10.00)	61 (24.40)	164 (65.60)	250 (100)
Girls	0	80 (33.33)	49 (20.83)	111 (45.83)	240 (100)
8 years					
Boys	5 (2.78)	16 (8.34)	54 (31.11)	105 (57.78)	180 (100)
Girls	0	25 (8.47)	119(40.34)	151 (51.86)	295 (100)
9 years					
Boys	0	34 (14.58)	112 (45.83)	94 (39.58)	240 (100)
Girls	10 (2.44)	76 (18.29)	148 (36.59)	176 (42.68)	410 (100)
10 years					
Boys	0	25 (33.33)	20 (26.67)	30 (40)	75 (100)
Girls	0	125 (23.58)	130 (24.53)	275 (51.89)	530 (100)
11 years					
Boys	0	46 (32.14)	54 (39.29)	40 (28.57)	140 (100)
Girls	15 (7.32)	74 (36.59)	71 (34.15)	45 (21.95)	205 (100)

12 years					
Boys	0	36 (11.48)	89 (29.51)	180 (59.02)	305 (100)
Girls	15 (11.54)	24 (19.23)	71 (53.85)	20 (15.38)	130 (100)
Boys	5 (0.42)	182 (15.29)	390 (32.77)	613 (51.51)	1190
Girls	40 (2.21)	404(22.32)	588 (32.49)	778 (42.98)	1810
Pooled	45 (1.5)	586 (19.53)	978 (32.6)	1391 (46.37)	3000

Ref. Gomez *et al*., (1956)   Figures in parenthesis indicate percentage

As observed from the Table 4.2., the school children with normal nutritional status were more among boys (51.51%) than girls (42.98%). Although not much gender difference was noticed in the prevalence of Grade I malnutrition, the more severe types like Grade II and Grade III were reported to be more among girls (Grade II – 22.32% and Grade III – 2.21%) than boys (Grade II - 15.29 % and Grade III - 0.42%).

Age-wise analysis also indicated the gender prominence, with boys by having more number of normal children in almost all age groups except with age of 9 and 10 years. Maximum number of sample with normal nutritional status was in the age group of 7 years among boys (65.6%) and 10 years among girls (51.89%). Also there observed a progressive decline in the percentage of children with normal nutritional status with the age advancement. This was accompanied by a corresponding increase in the Grade I and Grade II malnutrition. This trend was obvious among the male population than females. Moreover, girls seemed to be more malnourished than boys of the same age. This is a clear indication of nutritional stress among girls during puberty. This is further affirmed by the added incidence of moderate type (22.32%)

and severe type (2.21%) of malnutrition observed among girls. Only a very few number of boys had Grade III malnutrition (0.42%).

The present findings of the overall prevalence of severe malnutrition (1.5%) among the sample population is in line with the findings of Naik and Beegum, (2004), who observed the incident rate as 2 per cent.

The Figures 4. 3. and 4. 4. clearly illustrate the nutritional status of the sample as assessed by weight for age classification. The drawback of this classification is that sample with overweight and obesity cannot be distinguished from normal weight children. Weight for age percentiles have been developed for identifying the degree of malnutrition but it was also found to be unsuitable for identifying the obesity and overweight. Lower percentile weight-for-age cut-off points have been recommended by the World Health Organization to identify under-nutrition in some situations (WHO, 1995). However, less is known about the predictive value of weight-for-age at the upper end of the spectrum.

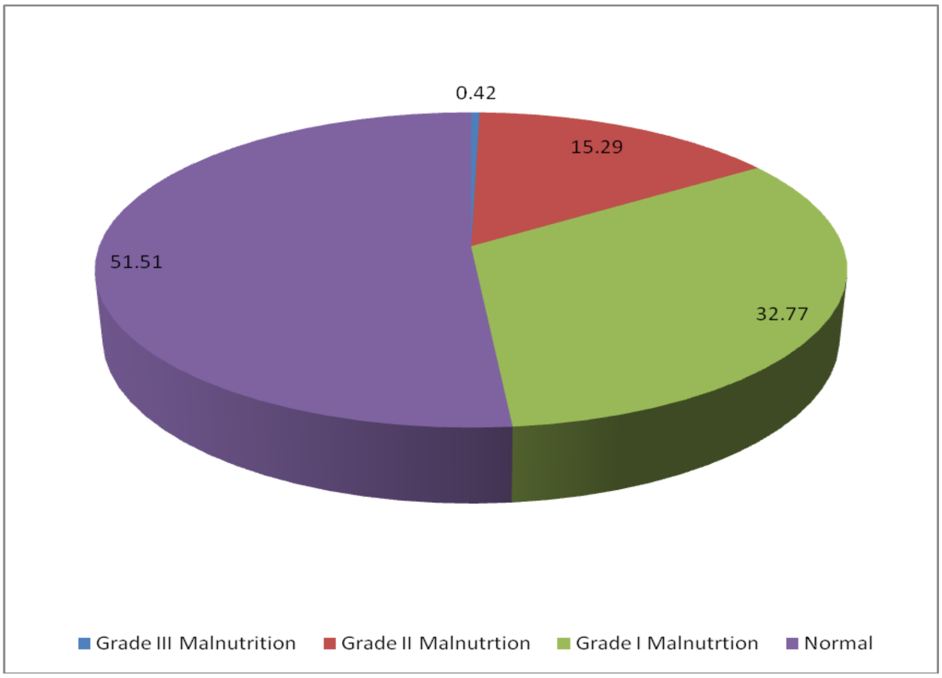

Figure 4. 3. Nutritional status of boys based on weight for age classification

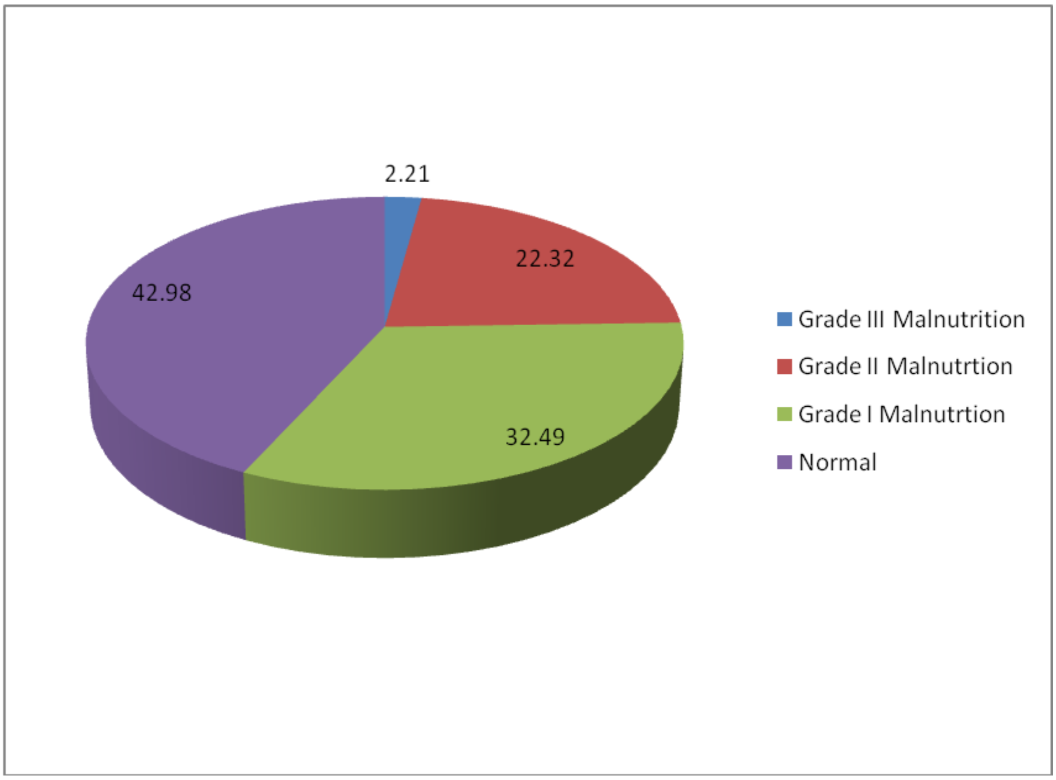

Figure 4. 4. Nutritional status of girls based on weight for age classification

Height for age classification

Based on height for age classification of Waterlow (1972) the sample was categorized to study their nutritional profile. The details are presented in Table 4. 3. Height is an indicator of long term nutritional status. Based on the height for age classification 81.01 per cent of boys and 73.26 per cent of girls were found to have normal heights and therefore the normal nutritional status. Marginal malnutrition was observed among 21.16 per cent of girls and 15.97 per cent of boys. Severe malnutrition (as stunting) was totally absent in both the groups. Boys in general exhibited a better profile in the height for age classification than girls. This may be due to the inability to meet additional requirement of nutrients for the growth spurt of girls.

Table 4. 3. Distribution of school children based on height for age classification

Age	Nutritional status based on height				Total
	≤ 85 Severe Malnutrition	**85 – 90 Moderate Malnutrition**	**90 – 95 Marginal Malnutrition**	**>95 Normal**	
7 years					
Boys	0	10 (4)	61 (24)	179 (72)	250 (100)
Girls	0	10 (4.17)	106 (43.75)	124(52.08)	240 (100)
8 years					
Boys	0	0	5 (2.78)	175 (97.22)	180 (100)
Girls	0	5 (1.69)	20 (6.78)	270 (91.53)	295 (100)
9 years					
Boys	0	0	22 (8.33)	218 (91.67)	240 (100)
Girls	0	16 (3.66)	50 (12.20)	344 (84.15)	410 (100)
10 years					
Boys	0	0	16 (20)	59 (80)	75 (100)
Girls	0	20 (3.77)	116 (21.70)	394 (74.53)	530 (100)
11 years					
Boys	0	0	30 (21.43)	110 (78.57)	140 (100)
Girls	0	25 (12.20)	55 (26.83)	125 (60.98)	205 (100)
12 years					
Boys	0	26 (8.20)	56 (18.03)	223 (73.77)	305 (100)
Girls	0	25 (19.23)	36 (26.92)	69 (53.85)	130 (100)
Boys	0	36 (3.03)	190 (15.97)	964 (81.01)	1190 (100)
Girls	0	101 (5.58)	383 (21.16)	1326 (73.26)	1810 (100)
Pooled	0	137 (4.57)	573 (19.1)	2290 (76.33)	3000 (100)

Ref : Waterlow, (1972)   Figures in parenthesis indicate percentage

Analysis based on age groups showed that irrespective of gender, the highest percentage of school children with normal nutritional status was in the age group of 8 years followed by 9, 10, 11 and 12 years. As in the case of body weight, a progressive reduction in the number of normal weight children with age (8 to 12 years) and the corresponding increase in first grade malnutrition was observed irrespective of gender.

The age group of 7 years (both boys and girls) had exceptionally less number of normal children and more of marginally malnourished children, with respect to height.

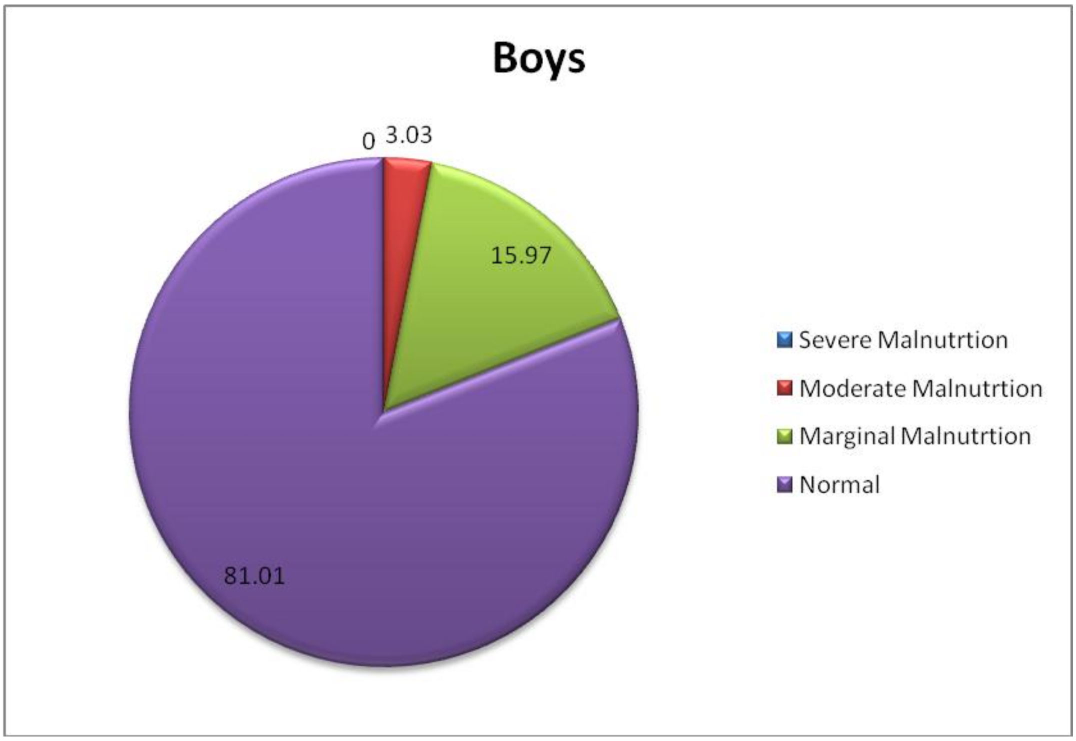

Figure 4. 5. Nutritional status of boys based on height for age classification

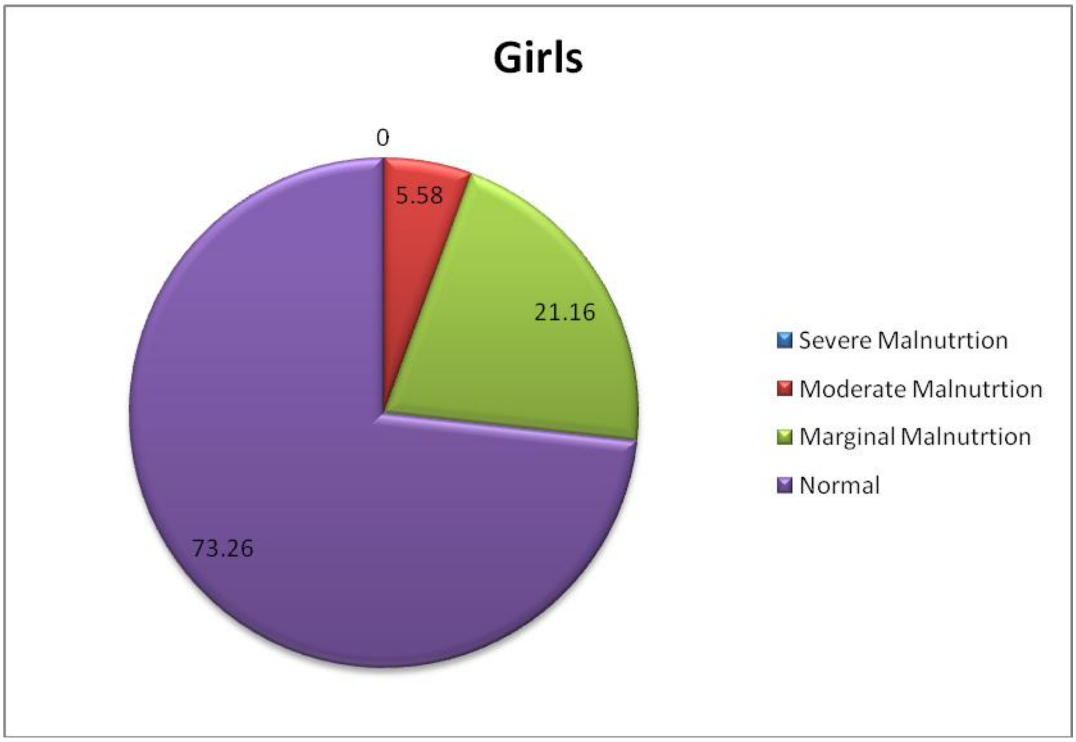

Figure 4. 6. Nutritional status of girls based on height for age classification

4. 1. 2. Body Mass Index

There is no commonly accepted standard for defining childhood obesity and it is still in controversy. Body mass index (BMI) of children of the present study was compared with adult BMI values given by James *et al*., (1988) and also with the modified BMI values for Asian adult population WHO (2000). The results are given in Table 4. 4. and 4. 5.

Nutritional status based on BMI classification revealed that chronic energy deficiency (Grade III) was the major problem (70.12 %) in children irrespective of age and gender. 72.35 per cent of boys and 67.91 per cent of girls were affected by CED Grade III. This was followed by Grade II malnutrition (10.07%) including 9.66% boys and 10.5% girls. Samples with normal BMI (5.66%) included slightly more number of girls (6.63%) than boys (4.18%). Overall prevalence of obesity was only 0.67 per cent as per James *et al*., (1988) classification.

A high prevalence of chronic energy deficiency of Grade III category was reported by Chaturvedi *et al*., (1996) among children of the age group of 10 to 15 years in Rajasthan. Similar findings were also reported by Panjikkaran and Usha, (2010), in which girls with CED Grade III was 44 percent and Grade II and Grade I were 18 per cent each.

Comparison of BMI of the sample with that of Asian population suggested by WHO (2000) is presented in Table 4. 5. Here also the same trend was seen in the percentage of normal children (5%) and also the incidence of grade II (0.67%) and Grade I (0.67%) obesity.

BMI Percentiles

Estimates of the prevalence of overweight and obesity in population groups are typically based on body mass index (BMI), and BMI centile curves have been developed for use in the paediatric population for clinical and possibly epidemiological purposes. A workshop organised by the International Obesity Task Force (IOTF) proposed to link adult cut-off points to BMI centiles for children to provide child cut-off points (Bellizi and Dietz, 1999; Dietz and Robinson, 1998). BMI percentiles were calculated using IOTF classification given by IAP (Khadilkar *et al*., 2007), Cole *et al*., (2000) and CDC (2000).

Cole *et al*. (2000) have given percentile values only for identifying overweight and obese children. Based on this classification, school going population (n=3000) under study was categorised and the details are given in Table 4.6. and Figure 4.7.

Among the total population (n = 3000) 9.8 % involving 3.1 % boys and 6.7 % girls were categorised as overweight and obese The prevalence rate was 7.1 per cent for overweight and 2.7 per cent for obesity among the study population.

Table 4. 4. Distribution of school children based on Body mass index

BMI*	Nutritional status	7 years		8 years		9 years		10 years		11 years		12 years		Pooled		Total
		Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	
<16.0	Chronic energy deficiency (CED) – Grade III	186 (15.63)	204 (11.27)	130 (10.92)	250 (13.81)	180 (15.13)	280 (15.47)	60 (5.04)	275 (15.19)	100 (8.40)	150 (8.29)	205 (17.23)	70 (3.87)	861 (72.35)	1229 (67.91)	2090 (70.12)
16.0– 17.0	(CED) – Grade II	34 (2.86)	16 (0.88)	5 (0.42)	20 (1.10)	30 (2.52)	10 (0.55)	0 (0.00)	89 (4.92)	21 (1.76)	30 (1.66)	25 (2.10)	25 (1.38)	115 (9.66)	190 (10.50)	305 (10.07)
17.0 – 18.5	(CED) – Grade I	5 (0.42)	15 (0.83)	5 (0.42)	5 (0.28)	0 (0.00)	35 (1.93)	5 (0.42)	71 (3.92)	9 (0.76)	5 (0.28)	20 (1.68)	25 (1.38)	44 (3.70)	156 (8.62)	200 (6.15)
18.5 – 20.0	Low normal	25 (2.10)	0 (0.00)	25 (2.10)	10 (0.55)	10 (0.84)	40 (2.21)	5 (0.42)	35 (1.93)	10 (0.84)	0 (0.00)	45 (3.78)	10 (0.55)	120 (10.08)	95 (5.24)	215 (7.66)
20.0 – 25.0	Normal	0 (0.00)	5 (0.28)	15 (1.26)	10 (0.55)	20 (1.68)	45 (2.49)	5 (0.42)	40 (2.21)	0 (0.00)	20 (1.10)	10 (0.84)	0 (0.00)	50 (4.18)	120 (6.63)	170 (5.66)
25.0 - 30	Obese – Grade I	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	20 (1.10)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	20 (1.10)	20 (0.67)

*Ref: James *et al*. (1988)

Figures in parenthesis indicate percentage

Table 4. 5. Distribution of school children based on Body mass index suggested for Asian adult population

BMI*	Nutritional status	7 years		8 years		9 years		10 years		11 years		12 years		Pooled		Total
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
<16.0	CED – Grade III	186 (15.63)	204 (11.27)	130 (10.92)	250 (13.81)	180 (15.13)	280 (15.47)	60 (5.04)	275 (15.19)	100 (8.40)	150 (8.29)	205 (17.23)	70 (3.87)	861 (72.35)	1229 (67.91)	2090 (70.12)
16.0– 17.0	CED – Grade II	34 (2.86)	16 (0.88)	5 (0.42)	20 (1.10)	30 (2.52)	10 (0.55)	0 (0.00)	89 (4.92)	21 (1.76)	30 (1.66)	25 (2.10)	25 (1.38)	115 (9.66)	190 (10.50)	305 (10.07)
17.0 – 18.5	CED – Grade I	5 (0.42)	15 (0.83)	5 (0.42)	5 (0.28)	0 (0.00)	35 (1.93)	5 (0.42)	71 (3.92)	9 (0.76)	5 (0.28)	20 (1.68)	25 (1.38)	44 (3.70)	156 (8.62)	200 (6.15)
18.5 – 20.0	Low normal	25 (2.10)	0 (0.00)	25 (2.10)	10 (0.55)	10 (0.84)	40 (2.21)	5 (0.42)	35 (1.93)	10 (0.84)	0 (0.00)	45 (3.78)	10 (0.55)	120 (10.08)	95 (5.24)	215 (7.66)
20.0 – 23.0	Normal	0 (0.00)	5 (0.28)	15 (1.26)	10 (0.55)	15 (1.26)	35 (1.93)	5 (0.42)	40 (2.21)	0 (0.00)	15 (0.89)	10 (0.84)	0 (0.00)	45 (3.78)	105 (5.86)	150 (5.00)
23.0 - 25	Obese – Grade I	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	5 (0.42)	10 (0.55)	0 (0.00)	0 (0.00)	0 (0.00)	5 (0.28)	0 (0.00)	0 (0.00)	5 (0.42)	15 (0.83)	20 (0.67)
25.0 - 30	Obese – Grade II	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	20 (1.10)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	20 (1.10)	20 (0.67)

*Ref: WHO (2000) Figures in parenthesis indicate percentage

Among the total population of 3000 school children only 9.8% (n=295) had the problem of either obesity or overweight. More girls (11.04%) than boys (7.89%) were affected in this respect. Among girls overweight (7.73%) was more prominent than obesity (3.31%).

Although the total number of boys affected with over-nutrition was comparatively less, the same trend as for girls, followed here also, such as boys with overweight (6.3%) outnumbered the boys with obesity (1.68%).

CDC Percentiles

The major drawback of the classification given by Cole *et al*. (2000) is that it does not give information about underweight and healthy children. Only overweight and obese children can be detected by this classification. Therefore CDC classification, which enables to assess the total weight abnormalities in children, was considered as appropriate.

Centres for Disease Control and Prevention (CDC, 2000) has formulated the obesity and overweight percentile values for school going children based on gender, age, weight and height. The tool for CDC percentile calculation is freely available at http://apps.nccd.cdc.gov/dnpabmi/Result.aspx and in the present study; the CDC percentiles values for the sample population were calculated online using this service. The cut-offs were established by comparing the CDC percentile values for the corresponding BMI values and given in Table 4.7.

Table 4. 6. Distribution of sample based on Body Mass Index percentiles for overweight and obesity

Age (Years)	Body Mass Index of boys (n=95)					Body Mass Index of girls (n=200)					Pooled
	Overweight		Obesity		Total	Overweight		Obesity		Total	
	BMI centile	Number	BMI centile	Number		BMI centile	Number	BMI centile	Number		
7	17.9	13 (17.33)	20.6	0 (0.00)	13 (13.68)	17.8	5 (3.57)	20.5	0 (0.00)	5 (2.50)	18 (6.10)
7.5	18.2	12 (16.00)	21.1	0 (0.00)	12 (12.63)	18	10 (7.14)	21	5 (8.33)	15 (7.50)	27 (9.15)
8	18.4	11 (14.67)	21.6	7 (35.00)	18(15.79)	18.3	0 (0.00)	21.6	10 (16.67)	10 (5.00)	28 (9.49)
8.5	18.8	14 (18.67)	22.2	8 (40.00)	22 (26.32)	18.7	5 (3.57)	22.2	0 (0.00)	5 (2.50)	27 (9.15)
9	19.1	7 (9.33)	22.8	0 (0.00)	7 (7.37)	19.1	16 (11.43)	22.8	25 (41.67)	41 (20.50)	48 (16.27)
9.5	19.5	13 (17.33)	23.4	5 (25.00)	18 (18.95)	19.5	29 (20.71)	23.5	0 (0.00)	29 (14.50)	47 (15.93)
10	19.8	5 (6.67)	24	0 (0.00)	5 (5.26)	19.9	27 (19.29)	24.1	5 (8.33)	32 (16.00)	37 (12.54)
10.5	20.2	0 (0.00)	24.6	0 (0.00)	0 (0.00)	20.3	28 (20.00)	24.8	15 (25.00)	43 (21.50)	43 (14.58)
11	20.6	0 (0.00)	25.1	0 (0.00)	0 (0.00)	20.7	5 (3.57)	25.4	0 (0.00)	5 (2.50)	5 (1.69)
11.5	20.9	0 (0.00)	25.6	0 (0.00)	0 (0.00)	21.2	15 (10.71)	26.1	0 (0.00)	15 (7.50)	15 (5.08)
12	21.2	0 (0.00)	26	0 (0.00)	0 (0.00)	21.7	0 (0.00)	26.7	0 (0.00)	0 (0.00)	0 (0.00)
% of total population (boys-n=1190, girls-n=1810, Total = 3000)		75 (6.30)		20 (1.68)	95 (7.98)		140 (7.73)		60 (3.31)	200 (11.04)	295 (9.80)
% share of overweight and obesity among the affected population		75 (78.95)		20 (21.05)	95 (100)		140 (70.00)		60 (30.00)	200 (100)	295

Ref : Cole *et al*. (2000) Figures in parenthesis indicate percentage

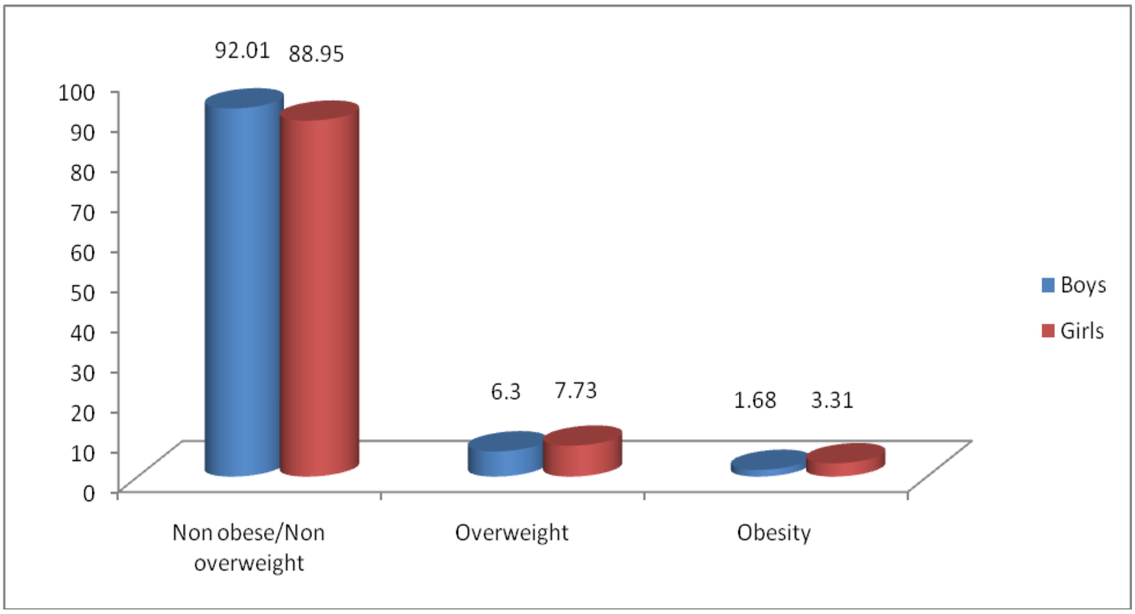

Figure 4. 7. Percentage share of overweight and obese children according to BMI percentiles (Cole *et al*., 2000)

Distribution of school children based on Body mass index percentiles given by CDC (2000) was calculated and the results are given in Table 4.8. and Figure 4.8. The Table 4.8. shows that malnutrition in the form of under-nutrition was more severe among the sample population than over-nutrition. 45.71 per cent of boys and 35.86 per cent of girls were undernourished. Normal weight for age was reported by 50.87 per cent of the sample. Gender specific analysis indicated that more number of girls (54.75%) had normal healthy weight than boys (45.04%). Similarly the prevalence rate of overweight was slightly more among boys (7.56%) than girls (6.08%). Obesity prevalence, as per the study, was reported more among girls (3.31%) than boys (1.68%).

Table 4. 7. Corresponding BMI values for calculated CDC percentiles suitable for children between 7 to 12 years

Age (Yrs)	Gender	Corresponding BMI for CDC percentile for underweight **CDC percentile < 5**	Corresponding BMI for CDC percentile for healthy weight **CDC percentile 5 - 85**	Corresponding BMI for CDC percentile for overweight **CDC percentile 85-95**	Corresponding BMI for CDC percentile for obesity **CDC percentile >95**
7	Boys	< 13.52	13.52 – 17.92	17.93 – 21.32	> 21.32
	Girls	< 13.44	13.44 – 17.75	17.76 – 21.03	> 21.03
8	Boys	< 13.71	13.71 – 18.22	18.23 – 21.53	> 21.53
	Girls	< 13.51	13.51 – 18.11	18.12 – 21.44	> 21.44
9	Boys	< 13.92	13.92 – 19.30	19.31 – 22.80	> 22.80
	Girls	< 13.8	13.8 – 19.20	19..21 – 22.75	> 22.75
10	Boys	< 14.13	14.13 – 19.68	19.69 – 23.50	> 23.50
	Girls	< 14.13	14.13 – 19.75	19.76 – 23.80	> 23.80
11	Boys	< 14.59	14.59 – 20.78	20.79 – 25.40	> 25.40
	Girls	< 14.48	14.48 – 20.90	21.0 – 25.80	> 25.80
12	Boys	< 14.92	14.92 – 21.54	21.55 – 26.53	> 26.53
	Girls	< 14.88	14.88 – 21.82	21.83 -26.90	> 26.90

To sum it could be stated that although the overall prevalence of obesity (2.67%) and overweight (6.67%) was comparatively low, among the study population, the situation demands urgent attention, as a warning note of the future health complications of our younger generation. Coexistence of under and over nutrition among around 50 per cent of our school children is yet another matter of great concern.

Indian Academy of Paediatrics, (Khadilkar *et al*., 2007) has given percentiles suitable for Indian population. The percentile values computed were compared with standard values and are presented in Table 4. 9.

The total prevalence of overweight and obesity was found to be 6.67 per cent. According to this classification a greater prevalence of obesity (8.57%) and overweight (2.27 %) was seen among boys when compared to girls with 3.09 % of obese and 0.82% overweight respectively.

As per Khadilkar's classification 200 children including 129 boys and 71 girls had either overweight or obesity constituting 6.67 per cent of total population. The remaining 93.33 per cent was non obese and non overweight.

Comparison of different BMI percentiles of the sample

BMI percentiles of the sample were calculated using classification given by Cole *et al*. (2000), CDC (2000) and IAP (Khadilkar *et al*., 2007) and the results are presented in Table 4.10.

Table 4. 8. Distribution of school children based on Body mass index percentiles (CDC, 2000)

BMI	Boys (Age in years)							Girls (Age in years)							Grand Total
	7	8	9	10	11	12	Total	7	8	9	10	11	12	Total	
Underweight < 5th percentile Number (%)	81 (14.89)	73 (13.42)	100 (18.38)	45 (8.27)	75 (13.79)	170 (31.25)	544 (100.00)	115 (17.72)	122 (18.80)	139 (21.42)	150 (23.11)	83 (12.79)	40 (6.16)	649 (100)	1193
Per cent of total sample size							544 (45.71)							649 (35.86)	1193 (39.80)
Normal weight 5th to 85th percentile Number (%)	144 (26.87)	66 (12.31)	116 (21.64)	25 (4.67)	50 (9.33)	135 (25.19)	536 (100)	105 (10.60)	154 (15.54)	195 (19.68)	325 (32.80)	122 (12.31)	90 (9.08)	991 (100)	1526
Per cent of total sample size							536 (45.04)							991 (54.75)	1526 (50.87)
Overweight 85th to < 95th percentile Number (%)	25 (27.78)	26 (28.89)	19 (21.11)	5 (5.56)	15 (16.67)	0 (0.00)	90 (100)	15 (13.64)	9 (8.19)	51 (46.36)	35 (31.82)	0 (0.00)	0 (0.00)	110 (100)	200
Per cent of total sample size							90 (7.56)							110 (6.08)	200 (6.67)
Obese ≥ 95th percentile Number (%)	0 (0.00)	15 (75)	5 (25)	0 (0.00)	0 (0.00)	0 (0.00)	20 (100)	5 (8.33)	10 (16.67)	25 (41.67)	20 (33.33)	0 (0.00)	0 (0.00)	60 (100)	80
Per cent of total sample size							20 (1.68)							60 (3.31)	80 (2.67)

Figures in parenthesis indicate percentage

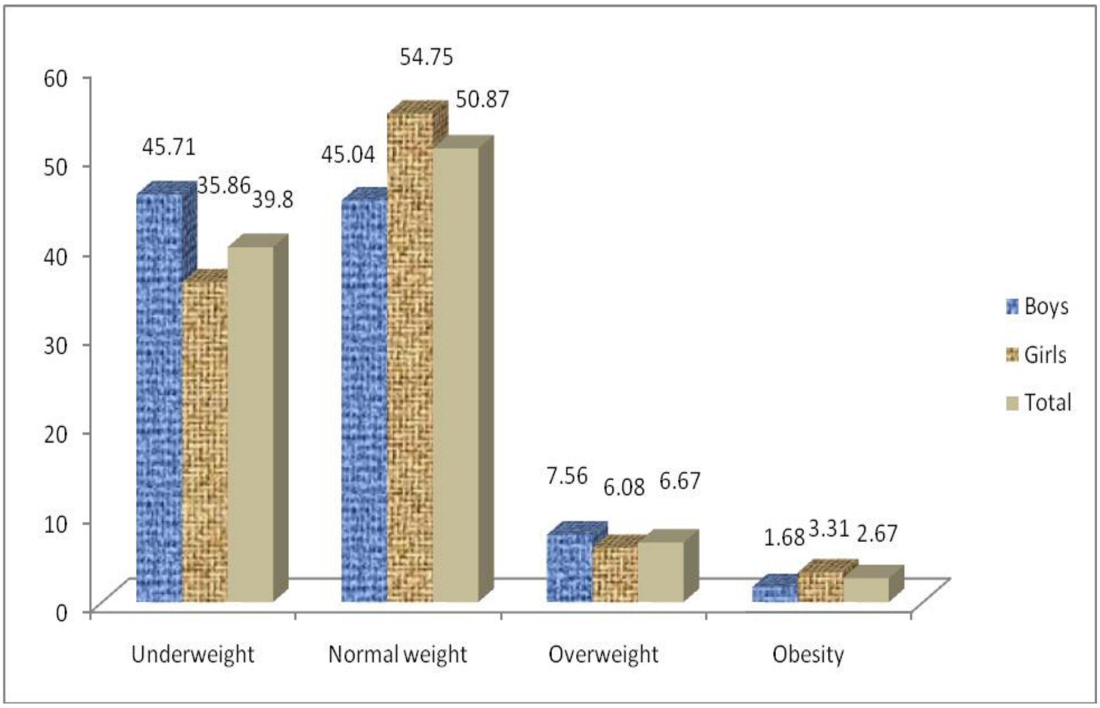

Figure 4. 8. Nutritional status of children based on BMI percentiles (CDC, 2000)

While using the classification given by Khadilkar *et al*. (2007), the prevalence of overweight in boys and girls was found to be very low. Among boys, the prevalence of obesity was more (8.57 %) in comparison with other classifications (1.68 %). CDC has the advantage of identifying the underweight and healthy weight children along with overweight and obesity. Hence the sub sample selected for further study is based on CDC percentiles. The prevalence of obesity/overweight being more than 5 per cent, it could be considered as a chronic epidemic which requires attention of health professionals and social workers. Apart from this, the study also points that under weight and chronic energy deficiency (CED) is more severe even now, when compared to overweight/obesity. This indicates the coexistence of under as well as over-nutrition, a typical scenario in developing countries like India.

The percentage of prevalence of overweight and obesity using the three classifications of BMI percentiles at a glance is presented in Table 4.11.

Table 4. 9. Distribution of school children based on Body mass index percentiles suggested by Khadilkar *et al*. (2007)

Age (Years)	BMI of boys (n=129)					BMI of girls (n=71)					Pooled
	Overweight		Obesity		Total Number (%)	Overweight		Obesity		Total Number (%)	
	BMI centile	Number (%)	BMI centile	Number (%)		BMI centile	Number (%)	BMI centile	Number (%)		
7.0	16.4	5 (18.51)	16.8	14 (13.73)	19	18.8	0 (0.00)	19.9	6 (10.71)	6	25 (12.50)
7.5	16.7	7 (25.93)	17.1	13 (12.75)	20	19.3	0 (0.00)	20.5	0 (0.00)	0	20 (10.00)
8.0	17	0 (0.00)	17.5	26 (25.49)	26	19.9	0 (0.00)	21.0	5 (8.93)	5	31 (15.50)
8.5	17.2	0 (0.00)	18.0	19 (18.63)	19	20.5	0 (0.00)	21.5	5 (8.93)	5	24 (12.00)
9.0	17.6	0 (0.00)	18.5	9 (8.82)	9	21.0	0 (0.00)	22.1	15 (26.79)	15	24 (12.00)
9.5	17.9	0 (0.00)	19.1	16 (15.69)	16	21.6	5 (33.33)	22.7	10 (17.86)	15	31 (15.50)
10.0	18.2	0 (0.00)	19.6	0 (0.00)	0	22.0	0 (0.00)	23.2	10 (17.86)	10	10 (5.00)
10.5	18.4	0 (0.00)	20.2	5 (4.90)	5	22.6	4 (26.67)	23.9	5 (8.93)	9	14 (7.00)
11.0	18.9	2 (7.41)	20.8	0 (0.00)	2	23.1	2 (13.33)	24.5	0 (0.00)	2	4 (2.00)
11.5	19.3	3 (11.11)	21.2	0 (0.00)	3	23.7	4 (26.67)	25.1	0 (0.00)	4	7 (3.50)
12.0	19.8	10 (37.04)	21.8	0 (0.00)	10	24.1	0 (0.00)	25.7	0 (0.00)	0	10 (5.00)
% of total population (boys-n=1190, girls-n=1810, Total = 3000)		27 (2.27)		102 (8.57)	129 (10.84)		15 (0.82)		56 (3.09)	71 (3.92)	6.67
% share of overweight and obesity among the affected population		27 (20.93)		102 (79.07)	129 (100)		15 (21.13)		56 (78.87)	71 (100)	200 (100)

Ref: Khadilkar *et al*. (2007) Figures in parenthesis indicate percentage

Table 4. 10. BMI percentiles of the sample computed based on three standard classifications

Age (years)	Cole *et al*. (2000) n=295				CDC, (2000) n=280				Khadilkar *et al*. (2007) n=200			
	Overweight		Obese		Overweight		Obese		Overweight		Obese	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
7	25	15	0	5	25	15	0	5	12	0	27	6
8	25	5	15	10	26	9	15	10	0	0	45	10
9	20	45	5	25	19	51	5	25	0	5	25	25
10	5	55	0	20	5	35	0	20	0	4	5	15
11	0	20	0	0	15	0	0	0	5	6	0	0
12	0	0	0	0	0	0	0	0	10	0	0	0
% of population (boys-n=1190, girls-n=1810, Total = 3000)	75 (6.30)	140 (7.73)	20 (1.68)	60 (3.31)	90 (7.56)	110 (6.08)	20 (1.68)	60 (3.31)	27 (2.27)	15 (0.83)	102 (8.57)	56 (3.09)
% share of overweight and obesity among the affected population	75 (78.95)	140 (70.00)	20 (21.05)	60 (30.00)	90 (81.82)	110 (64.71)	20 (18.18)	60 (35.29)	27 (20.93)	15 (21.13)	102 (79.07)	56 (78.87)

Figures in parenthesis indicate percentage

Table 4. 11. Comparison of BMI percentiles of the sample

Percentiles	**Overweight** Boys (%) (n=1190)	**Overweight** Girls (%) (n=1810)	**Obesity** Boys (%) (n=1190)	**Obesity** Girls (%) (n=1810)	**Total (%) (n=3000)**
Cole *et al*., (2000)	75 (6.30)	140 (7.73)	20 (1.68)	60 (3.31)	295 (9.84)
CDC, (2000)	90 (7.56)	110 (6.08)	20 (1.68)	60 (3.31)	280 (9.34)
Khadilkar *et al*., (2007)	27 (2.27)	15 (0.83)	102 (8.57)	56 (3.09)	200 (6.67)

Figures in parenthesis indicate percentage

4. 1. 3. Waist and Hip circumferences/ Ratio

Waist circumference

Waist circumference (WC) was suggested as a tool for screening children with central obesity because of its sensitivity and specificity (Goran *et al*., 1998; Taylor *et al*., 2000). WC was also found to be a sensitive marker of cardiovascular risk in children (Maffeis *et al*., 2001). The details on the waist circumference of the sample are given in Table 4.12.

Table 4. 12. Mean waist circumference of the sample

Age (Years)	**Waist circumference (cm)**			
	Boys Mean±SD	**Number**	**Girls Mean±SD**	**Number**
7	57.60±7.11	250	53.42±4.95	240
8	56.33±8.52	180	54.81±5.83	295
9	53.77±6.20	240	56.20±8.28	410
10	54.46±5.87	75	57.59±5.95	530
11	55.27±7.98	140	57.87±8.16	205
12	56.74±7.96	305	59.15±5.58	130

As obtained from the table there was a progressive increase in waist circumference of girls with age. It ranged between 53.42 ± 4.95 cm to 59.15 ± 5.58 cm. In the case of boys there observed a progressive decline in waist circumference from 7 years (57.60 ± 7.11 cm) to 9 years (53.77 ± 6.20 cm) and thereafter a steady increase throughout the age of 10 to 12 years. A progressive increase in waist circumference with age was reported by Janssen *et al*., (2002a) and Lean *et al*., (1995) and has also suggested as a measure for indicating need for weight management.

Higgins *et al*., (2001) has given the cut off points to describe an adequate health related definition of childhood obesity. Waist circumference cut-points indicative of moderate and severe cardiovascular risk factor profiles were 61cm – 71 cm and ≥71 cm, respectively for pre pubertal children. Number of children coming under this cut offs were worked and the result is given in Table 4.13.

Cardiovascular risk factors are associated with obesity and overweight. (Abate, 2000). In childhood also obesity seems to lead to the appearance of a number of cardiovascular risk factors, such as altered lipid levels (Friedland *et al.,* 2005) and impaired glucose tolerance (Sinha *et al*., 2002), which could contribute to atheroma plaque development and lead to the development of coronary heart disease in adult life (Freedman *et al*., 2001). From the table it is observed that majority of boys (77.39%) and girls (77.79%) were seemed to be out-of-risk of CVD as their waist circumference was within the reference value recommended by Higgins *et al*., (2001). Moderate risk factor for cardiovascular diseases was seen among 13.61 and 16.74 per cent respectively of boys and girls studied. WC as a strong predictor of cardiovascular diseases was observed among 8.99 and 5.17 per cent of boys and girls respectively.

Table 4. 13. Distribution of the sample based on cut-off values of waist circumference

Age (Years)	Waist circumference					
	Boys (n=1190)			Girls (n=1810)		
	≤ 61 cm No risk	61 cm-71 cm Moderate	≥71 cm Severe	≤ 61 cm No risk	61 cm-71 cm Moderate	≥71 cm Severe
7	183 (15.38)	58 (4.87)	9 (0.76)	214 (11.82)	24 (1.33)	2 (0.11)
8	130 (10.92)	31 (2.61)	19 (1.60)	259 (14.31)	33 (1.82)	3 (0.17)
9	193 (16.22)	18 (1.51)	29 (2.44)	312 (17.24)	63 (3.48)	35 (1.93)
10	52 (4.37)	9 (0.76)	14 (1.18)	373 (20.61)	119 (6.57)	38 (2.10)
11	124 (0.42)	11 (0.92)	5 (0.42)	167 (9.23)	28 (1.55)	10 (0.55)
12	239 (20.1)	35 (2.94)	31 (2.61)	83 (4.59)	36 (1.99)	11 (0.61)
Total	921 (77.39)	162 (13.61)	107 (8.99)	1408 (77.79)	303 (16.74)	99 (5.17)

Ref: Higgins *et al*., (2001) Figures in parenthesis indicate percentage

Waist circumference percentiles

Waist circumference measurement has proved to be a useful tool for assessing risk for obesity related diseases such as cardiovascular disease in adult population (Lemieux *et al.*, 2000). Waist circumference has been shown to correlate well with intra-abdominal fat mass (Lean *et al.*, 1995), which in turn has been shown to be related to an atherogenic lipoprotein profile (Han *et al*., 1995).

McCarthy *et al*. (2001) has given standards for waist circumference percentiles for identifying overweight and obese children. Since the percentile values are only available for overweight and obese, children belonging to this category were identified and are presented in Table 4.14.

Table 4. 14. Distribution of school children based on waist circumference percentiles for obesity and overweight

Age (Years)	Boys (n=1190)				Girls (n=1810)			
	Overweight		Obese		Overweight		Obese	
	Percentiles	Number	Percentiles	Number	Percentiles	Number	Percentiles	Number
7.0	58.8	6	60.7	118	58.7	24	60.8	25
8.0	60.9	12	62.9	41	60.4	7	62.7	32
9.0	63.2	0	65.4	25	62.0	16	64.5	133
10.0	65.6	0	67.9	6	63.6	43	66.2	133
11.0	67.9	0	70.4	26	65.4	126	68.1	2
12.0	70.4	0	72.9	19	67.3	10	70.5	10
% of total population (boys- n=1190, girls- n=1810, Total = 3000)		18 (1.52)		235 (19.74)		226 (12.49)		335 (18.51)
% share of overweight and obesity among the affected population		18 (7.11)		235 (92.89)		226 (40.29)		335 (59.71)

Ref : McCarthy *et al*., (2001)

Figures in parenthesis indicate percentage

Analysis based on waist circumference percentiles revealed an overall prevalence of overweight and obesity among 814 children (27.13%). Obesity was more prevalent among boys and girls compared to overweight.

Until recently, waist circumference in children had not been regarded as being an important measure of adiposity. During growth in childhood, body fat is laid down both subcutaneously and intra-abdominally (Brambilla *et al*., 1994). The distribution of fat between the subcutaneous and intra-abdominal sites is likely to vary with both age and as a result of excessive body fat accumulation (Fox *et al*., 1993).

The health risks associated with an excessive abdominal fat distribution in children in comparison to adults remain unclear at this stage; although there is mounting evidence to suggest that concern should be raised. A strong association between increased waist circumferences with an atherogenic lipoprotein profile has been reported by many authors. The relationship between increasing waist circumferences in obese children aged 12 to 14 years with an adverse atherogenic lipoprotein profile has been observed by Flodmark *et al*. (1994).

Secondly, data from the Bogalusa Heart Study showed that an abdominal fat distribution (indicated by waist circumference) in children aged between 5 and 17 years was associated with adverse concentrations of triacylglycerol, LDL cholesterol, HDL cholesterol and insulin (Freedman *et al*., 1999). Such evidences now suggest that waist circumference in children could be as useful as BMI, as a means of identifying the overweight and obese in childhood population studies, and screening those children who could benefit from early dietary and exercise intervention. To these ends, waist circumference percentile curves have been generated for the Italian, Spanish and UK childhood populations (Moreno *et al*., 1999; Zannolli and Morgese, 1996).

Hence waist circumference percentiles developed by McCarthy *et al*. (2001) was used in this study to compare the prevalence rates of obese and overweight children obtained using other methods. The results are shown in table 4.14. It was observed from the table that overweight were less common among boys than girls. Overweight population among boys was only 1.52 per cent compared to girls (12.49 %) and prevalence of obesity was 19.74 per cent among boys and 18.51 per cent among girls. Highest number of overweight children was in the group of 11 year old girls. Obesity, at the same time was more obvious among 9 and 10 year old girls and 7 year old boys. When compared to BMI centiles the percentage of children with overweight/obesity is greater in this assessment using waist circumference percentiles but in all methodologies the prevalence rate is more among girls compared to boys. This may be because boys are given more freedom to engage in outdoor play activities in Indian society than girls, thus resulting in increased energy expenditure and in turn reducing the fat accumulation.

Waist to height ratio

Waist to Height ratio is more sensitive than BMI as an early warning of health risks. It is significantly associated with all risk factors for obesity and metabolic syndrome and can predict morbidity and mortality in longitudinal studies, often better than BMI (Patel *et al*., 1999; Cox *et al*., 1996). Further, the use of waist to height ratio can often identify people within the moderate range of BMI who have a higher metabolic risk, almost certainly because it is more closely associated with central obesity (Hsieh *et al*., 2000). Waist to height ratio can be even more sensitive than waist circumference in several different populations possibly because it encompasses the adjustment to different statures (Sayeed *et al.*, 2003; Hsieh *et al*., 2003; Lin *et al*., 2002; Patel *et al*., 1999; Hsieh and Yoshinaga, 1995a; Lee *et al*., 1995) and because of the negative correlation of height to certain metabolic risk factors (Henriksson *et al*., 2001). WHTR may allow the same boundary value for children and adults. There is now growing evidence that WHTR can be used to predict risk in children (Kahn *et al.*, 2005; Hara *et al.*, 2002;Savva *et al.*, 2000). Since the height and waist circumference of children increases continually as they age, the same boundary value (WHTR- 0.5) could be used across all age groups (Ashwell and Hsieh, 2005; McCarthy and Ashwell, 2003).

Table 4. 15. Distribution of school children based on Waist to height ratio

Age (years)	Waist to height ratio (n=3000)			
	Boys (n=1190)		Girls (n=1810)	
	<0.5	**≥ 0.5**	**<0.5**	**≥ 0.5**
7	195	55	221	19
8	164	16	271	24
9	221	19	365	45
10	70	5	494	36
11	140	0	179	26
12	292	13	119	11
Total	1082 (90.92)	108 (9.08)	1649 (91.10)	161 (8.90)

Ref : McCarthy and Ashwell (2003); Ashwell and Hsieh (2005)

Figures in parenthesis indicate percentage

Distribution of school children based on Waist to height ratio (McCarthy and Ashwell 2003; Ashwell and Hsieh, 2005) is presented in Table 4.15. It is observed from the table that increased risk for the development of obesity related metabolic syndromes was there among 9.08 per cent of boys and 8.90 per cent of girls. But majority of boys (90.92%) and girls (91.10%) were on the safer side with a waist to height ratio less than 0.5.

Waist circumference has been shown to be a better marker than BMI in predicting cardiovascular risk in both adults (Taylor *et al*., 2000; Dobbelsteyn *et al*., 2001; Zhu *et al*., 2002) and children (Savva *et al.*, 2000). More recently, an increasing number of studies documented that the ratio of waist circumference to height (WHTR), (Kuczmarski *et al*., 1994) was even superior to waist circumference and BMI to predict cardiovascular risk factors both in Japanese adults (Hsieh *et al*., 2003) and European and Asian children (McCarthy *et al*., 2006; Savva *et al.*, 2000). The value of 0.5 was suggested as an appropriate cut-off point for both adults and children (McCarthy *et al*., 2006).

WHTR has several advantages over BMI as it is less correlated with age than BMI, it makes it possible to propose a non-age-dependent cut off point, WHTR is a simple, easy, inexpensive, and accurate index for identifying overweight and obesity in children and adolescents. The cut-off point of WHTR as suggested by Yan *et al*. (2007) is 0.445 for both boys and girls to indicate overweight whereas the cut off point for obesity is 0.485 for boys and 0.475 for girls.

Classification based on Yan *et al*. (2007) showed a high prevalence rate of overweight and obesity when compared to the classification of McCarthy and Ashwell (2003). Gender wise analysis indicated that obesity was high among girls (14.86%) compared to boys (11.26%) whereas overweight was more among boys

(11.76%) than girls (6.24%). The high level variation in the obesity prevalence arrived through different cut-off value points that all these cut-offs are population specific. This cautions on the necessity to divert the efforts to standardise the Indian cut-off values on child obesity.

Table 4. 16. Distribution of school children based on cut-off points of WHTR

Age (Years)	Waist to height ratio (n=656)			
	≥ 0.445 (Overweight)		**≥ 0.485** Obesity	**≥ 0.475** Obesity
	Boys	Girls	Boys	Girls
7	36	19	63	41
8	41	23	30	31
9	24	25	15	80
10	11	34	11	93
11	6	7	1	12
12	22	5	14	12
% of total population (boys- n=1190, girls- n=1810, Total = 3000)	140 (11.76)	113 (6.24)	134 (11.26)	269 (14.86)
% share of overweight and obesity among the affected population	140 (51.09)	113 (29.58)	134 (48.91)	269 (70.42)

Ref : Yan *et al*., (2007) Figures in parenthesis indicate percentage

BMI vs Waist to height ratio percentiles

Though a wide variety of definitions of child obesity are in use, no commonly accepted standards have emerged. During growth in childhood, body fat is laid down both subcutaneously and intra-abdominally, hence obtaining information on waist circumference in children could be as useful as BMI as a means of identifying the overweight and obese status in childhood population studies (Mc Carthy *et al*., 2001). Waist circumference as a measure of obesity and overweight status suffers from the disadvantage of not considering important criteria such as body weight and height.

A waist-to-height ratio (W/Ht) has been reported to be an effective predictor of metabolic risks in all related investigations, which may be due to better measurement of the relative fat distribution among subjects of different ages and statures and the possible independent effect of height on the metabolic risks in addition to its independent effect on coronary disease itself (Bertsias *et al*., 2003; Ho *et al*., 2003; Hara *et al*., 2002). Waist-to-height ratio has also been reported to have closer values between men and women than BMI or waist circumference; therefore, the same boundary value may apply to both men and women. Meanwhile, a waist-to-height ratio of 0.5 may be a simple and effective index not only to identify overweight children, but also to identify children within the normal weight range (Bellizi and Dietz, 1999). Even then, a perfect relation of this factor with obesity or overweight status is yet to be standardized and efforts in this line have only shown that individuals with scores above 0.5 are likely to fall in the category of either overweight or obese, irrespective of age (Ashwell and Hsieh, 2005).

At this juncture, a new methodology was prepared that considers all the growth dynamics by combining BMI with waist-to-height ratio for establishing standard obesity percentiles among school going children. Details on the prevalence of obesity and overweight status among school going children in India were gathered using the established standards. These results were compared to assess their relative efficiencies in relation to the expected levels in the Indian population (Panjikkaran and Kumari, 2009). Age wise percentiles combining BMI and waist to height ratio for school going children is shown in Figure 4.9.

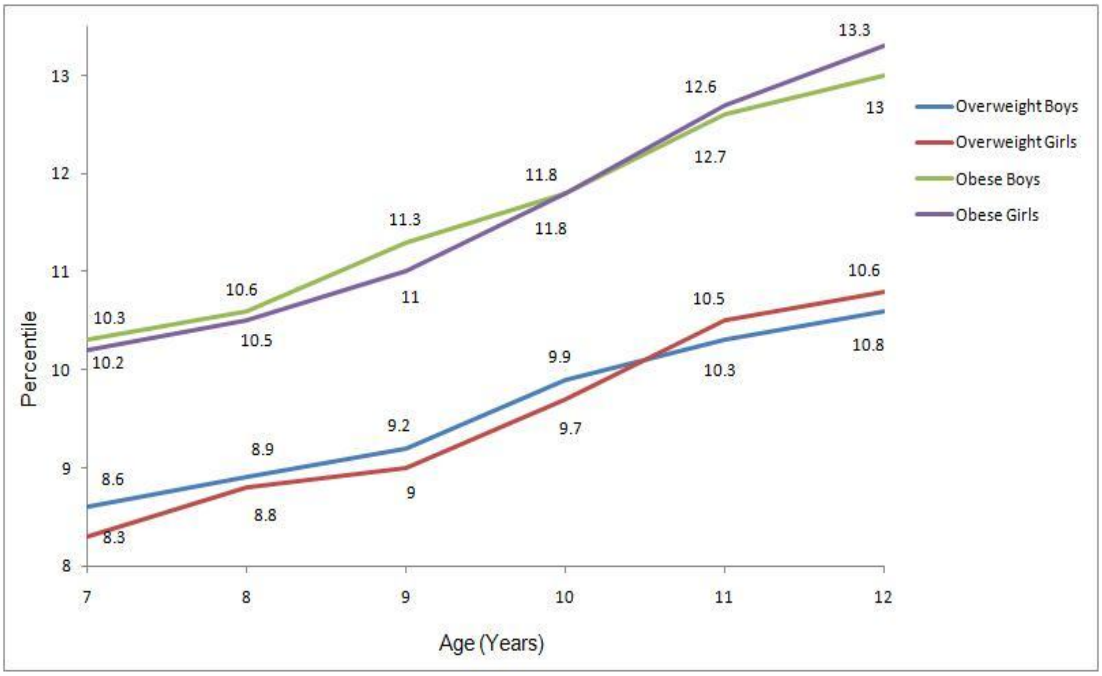

Figure. 4. 9. Age-wise Percentiles combining BMI and Waist to height Ratio of school children

Based on this augmented values overweight and obese children were classified in this study and the results are presented in Table 4.17.

Table 4. 17. Distribution of school children based on BMI X Waist to height ratio percentiles

Age (Years)	BMI X Waist to height ratio percentiles for boys (n=1190)				BMI X Waist to height ratio percentiles for girls (n=1810)				Total (n=3000)
	Overweight		**Obese**		**Overweight**		**Obese**		
	Centiles	Number	Centiles	Number	Centiles	Number	Centiles	Number	
7	8.6	31	10.3	0	8.3	16	10.2	6	53
8	8.9	29	10.6	13	8.8	9	10.5	11	62
9	9.2	19	11.3	14	9	45	11	29	107
10	9.9	05	11.8	0	9.7	40	11.8	14	59
11	10.3	15	12.6	0	10.5	2	12.7	0	17
12	10.6	01	13	0	10.8	0	13.3	0	1
		100 (8.40)		27 (2.27)		112 (6.19)		60 (3.31)	299 (9.97)

Ref : Panjikkaran and Kumari (2009) Figures in parenthesis indicate percentage

BMI merely takes into account weight and height, ignoring an equally important factor, waist circumference. The waist-to-height ratio considers waist circumference and height only, neglecting weight, the major indicator of obesity. The percentiles for school going children based on age and gender were derived by a comparison with all other accepted standards used for measurement of obesity and overweight status, and the superiority of the same over conventional methodologies was demonstrated and suitable standards for measuring obesity and overweight was established (Panjikkaran and Kumari, 2009).

Further, this methodology fails to differentiate the obese population from the overweight population. In the waist-to-height ratio methodology, there is neither consideration for body weight nor age-wise recommendation for children. Hence, the percentile values derived through combining BMI and waist-to-height ratio are more reliable for determining obesity and overweight status in school children.

The overall prevalence of overweight and obesity in this study was found to be more than 9 per cent. This is similar to the findings of studies conducted in Kerala Ramachandran, (2004) and Geetha, (2003). Ramachandran, (2004) reported the prevalence of overweight in girls and boys as 5.4 and 3.8 per cent respectively, and the prevalence of obesity in girls and boys as 0.2 and 1.3 per cent respectively. A study conducted on 1000 high school children (girls) of Thiruvananthapuram also revealed 5.4 percent and 2.2 percent of overweight and obesity respectively (Geetha, 2003). Raj *et al*., (2007) reported a raising trend in percentages prevalence of overweight and obesity during 2003 and 2005. In urban areas the prevalence increased from 6.43 to 8.66, and in rural areas the prevalence raised from 2.91 to 3.75 within a span of two years. In a study conducted at Delhi by Kapil *et al*. (2002) the overall prevalence of obesity was 7.4 percent in children from affluent families.

The results presented in Table 4.18. shows that CDC percentiles and BMI X WHTR were more efficient or provided almost similar results in the percentage of prevalence of overweight/obesity among the sample . In case of overall prevalence all classifications yielded almost similar results. Hence these classifications may be considered as standards for defining childhood obesity.

Table 4. 18. Percentage of overweight/ obese children as arrived by different percentile parameters

Percentiles	Boys		Girls		Total (%)
	Overweight	**Obese**	**Overweight**	**Obese**	
BMI percentiles Cole *et al*. (2000)	75 (6.30)	20 (1.68)	140 (7.73)	60 (3.31)	9.84
BMI percentiles CDC (2000)	90 (7.56)	20 (1.68)	110 (6.08)	60 (3.31)	9.34
BMI X WHTR Panjikkaran and Kumari (2009)	100 (8.40)	27 (2.27)	112 (6.19)	60 (3.31)	9.97
Waist to height ratio ≥ 5.0 McCarthy and Ashwell (2003); Ashwell and Hsieh (2005)	108 (9.08)		161 (8.90)		8.96

Figures in parenthesis indicate percentage

The gender wise distribution of overweight and obesity among the sample is presented in Table 4.19.

Table 4. 19. Gender wise distribution (%) of overweight and obesity among the sample

Percentiles	Boys (Per cent of n=1190)			Girls (Per cent of n=1810)			Total
	Overweight	**Obese**	**Total**	**Overweight**	**Obese**	**Total**	(n=3000)
BMI percentiles Cole *et al*., (2000)	6.30	1.68	7.98	7.73	3.31	11.05	9.84
BMI percentiles CDC, (2000)	7.56	1.68	9.24	6.08	3.31	9.39	9.34
BMI X WHTR Panjikkaran and Kumari, (2009)	8.40	2.27	10.67	6.19	3.31	14.45	9.93

Obesity seems to be a growing problem regardless of gender. But it can be noted that there is a gender-wise variation in the prevalence of overweight and obesity among children irrespective of the place as revealed in many studies in India and abroad. The present study also attempted to explore the gender wise variation in obesity prevalence. It was found that incidence among girls was more than boys. On the contrary, studies by Kapil *et al.* (2002) indicated a higher prevalence of obesity among boys (8%) as compared to girls (6%). Another study conducted by Unnithan and Syamakumari (2008) also showed a higher incidence of overweight (18.80%) and obesity (5.99%) among boys than girls (overweight–16.39% and obesity–3.79%). But studies by Mudur (2003) in three major Indian cities found that more girls were overweight and obese than boys. All these studies therefore indicate that the gender has an influence on prediction of overweight and obesity.

Waist to hip ratio

Relative fat distribution can be measured by the ratio of waist circumference to hip circumference (WHR). This was shown to be a good predictor of health risk and was popular for many years. However, although very useful for risk assessment, WHR is not helpful in risk management in a public health context, because both waist and hip circumferences can decrease with weight reduction and so the WHR does not change much (Bjorntorp, 1988). So, a comparison of mean values of hip circumference and waist to hip ratio was calculated and the results are given in Table 4.20.

Table 4. 20. Hip Circumference and Waist-to-Hip ratio of the sample

Age (Years)	Hip circumference (cm) (Mean±SD)		Waist-to-Hip ratio (cm) (Mean±SD)	
	Boys	**Girls**	**Boys**	**Girls**
7	66.76±7.06	60.88±4.92	1.16±0.058	1.14±1.260
8	67.11±8.34	65.44±5.52	1.20±0.057	1.20±0.080
9	65.69±5.89	68.01±7.53	1.23±0.056	1.22±0.081
10	67.53±6.49	71.49±7.23	1.23±0.079	1.24±0.094
11	69.25±5.04	72.22±7.62	1.24±0.074	1.24±0.127
12	70.84±6.70	73.5±6.62	1.26±0.089	1.24±0.070

There was consistent increase in hip circumference and waist-to-hip ratio with age among both boys and girls. There is also some evidence to indicate that it is a poorer measure of body fat distribution in children. But gender wise variation in the hip measurement was observed in the mean values, with girls having higher values than boys from the age group of 9 to 12 years indicating female growth spurt in puberty.

A larger WHR in adults indicates relatively larger amounts of abdominal fat and has been used to describe body fat distribution. However it is influenced by several other bodily factors. Waist to hip ratio is infrequently used in studies of children and adolescents (Moreno *et al*., 1997).

4. 1. 4. Mid Upper Arm Circumference (MUAC)

The mid upper arm circumference of school children were measured and the results are tabulated in Table 4.21.

Table 4. 21. Mean MUAC (cm) measurement of the sample

Age (Years)	Boys		Girls	
	Mean±SD	Number of samples	Mean±SD	Number of samples
7	19.15±2.64	250	17.46±1.60	240
8	19.31±3.28	180	18.71±1.91	295
9	18.83±2.40	240	19.61±2.99	410
10	19.13±2.20	75	19.76±2.47	530
11	19.61±2.27	140	20.07±2.89	205
12	20.03±2.84	305	20.50±1.90	130

A gradual increase in MUAC with age was observed in girls. The range was 17.46 ± 1.60 at the age of 7 years to 20.50 ± 1.90 at 12 years. An increase in MUAC with age is reported by Skybo and Wenger, (2003). Except in the age of 7 and 8 years, the MUAC measurements were higher among girls than boys.

4. 1. 5. Skinfold thickness

Triceps skinfold thickness is used as an index of body fat mass in children (Sarri *et al*., 2001). Several studies have reported a high correlation between fatness and skinfold thickness (Sarri *et al*., 2001; Sarri and Garcia, 1998) and per cent body fat derived from skinfolds (Eisenmann, *et al*., 2004).

The skinfold thickness of children was measured using Harpenden calipers. The mean values along with SD for each age group in comparison with the standard measurement given by WHO (1987) are presented in Table 4.22.

Table 4. 22. Mean triceps skinfold thickness (mm) of the sample

Age	Boys		Girls	
(Years)	Standard*	Mean±SD	Standard*	Mean±SD
7 -8	8.74±3.04	8.5±2.17	10.67±3.65	8.58±3.82
8-9	8.66±3.06	8.7±3.39	10.66±3.50	9.62±4.02
9-10	9.22±3.51	10.14±3.45	11.05±3.75	10.14±2.63
10-11	9.50±3.70	10.68±3.71	11.15±3.58	10.68±3.91
11-12	9.58±3.48	9.26±2.09	11.19±3.88	9.26±4.23
12-13	9.84±3.91	10.64±3.09	12.75±4.26	10.64±3.51

*Ref : WHO (1987)

The mean skinfold thickness of the sample also found to increase with age among both boys and girls, particularly in the younger age group of 7 to 11 years. At the age 10 years there observed a sudden drop, and then tended to increase. The triceps skinfold thickness as reported by Pratanaphon *et al*. (2007) for 6-8 year Chinese children was 11.8±6.5 and 12.8±5.6 for boys and girls respectively.

The fat fold thickness at biceps, subscapular and abdomen were taken and the mean values are presented in Table 4.23.

A comparison with standard values showed that among boys, except the age group of 7 and 11 years, the observed values were higher than the standard values. Whereas the observed values for skinfold measurement of girls were invariably lower than the standards, irrespective of age.

The overall picture of the skinfold measurement clearly brought out the fact that the girls were better placed in this respect than boys in all age groups except 11 years. A progressive increase in the biceps, sub scapular and abdomen skinfold measurements irrespective of gender, was yet another feature noticed especially among the younger groups (7 to 11 years).

Body fat percentage and skinfold thickness

Skin fold measurements alone can be used to assess body fat percentage. For girls of (5 to 18) years triceps skinfold of 9 mm corresponds to 15 percentage of body fat and for boys of the same age group triceps skin fold of 5 mm corresponds to 15 percentage of body fat. These values were established using the equations of Slaughter *et al*. (1988) to give the equivalent skinfold values for triceps and the results are given in Table 4.24.

Table 4. 23. Mean values of skinfold thickness (mm) of the sample

Age (Years)	Boys				Girls			
	Number	Biceps	Subscapular	Abdomen	Number	Biceps	Subscapular	Abdomen
7	250	4.56±1.06	6.78±1.76	7.09±2.13	240	5.26±2.17	6.77±3.13	6.62±3.80
8	180	4.69±1.82	6.03±2.67	7.08±4.77	295	5.4±2.50	7.74±3.34	9.01±4.69
9	240	5.72±2.28	7.97±4.69	8.52±6.36	410	6.05±1.94	9.64±2.59	10.53±3.49
10	75	6.10±2.16	8.22±5.28	11.16±6.82	530	6.39±2.62	10.31±3.22	11.45±6.44
11	140	5.41±1.62	9.57±2.77	11.08±4.19	205	6.94±1.94	8.31±5.86	8.74±7.16
12	305	5.37±1.72	9.49±4.81	10.94±5.77	130	6.53±1.78	9.88±5.25	10.92±7.14

Table 4. 24. Body fat percentage as equivalent of triceps skinfold thickness of the sample

Age (Years)	Children < 15 % body fat		Children > 15% body fat	
	Boys ≤ 5 mm Mean	Girls ≤ 9 mm Mean	Boys > 5 mm Mean	Girls > 9 mm Mean
7	3.24 (8)	7.36 (62.5)	11.56 (92)	11.52 (37.5)
8	2.09 (8.3)	6.36 (69.5)	12.42 (91.7)	11.87 (30.5)
9	4.30 (2.1)	7.56 (36.6)	10.68 (97.9)	15.53 (63.4)
10	4.90 (6.7)	7.6 (66.9)	10.85 (93.3)	15.33 (33.1)
11	3.87 (10.7)	7.87 (51.22)	9.38 (89.3)	13.67 (48.78)
12	3.66 (9.8)	7.86 (30.8)	11.46 (90.2)	11.87 (69.2)

Figures in parenthesis indicate percentage

From the table it was observed that majority of the boys (89.3 to 97.9%) had more than 15 per cent body fat irrespective of age. Whereas less number of girls (30.5 to 63.4%) compared to boys reported to have a higher (>15%) body fat percentage. This may be due to the fact that girls attain puberty or growth spurt earlier compared to boys where the fat deposit are used for growth and development.

4. 1. 6. Body density, body fat percentage and lean body mass

Body density was determined using the equation given by Ardle *et al*., (1986).

Body Density = 1.09665- (0.00103 X_1) – (0.00056 X_2) - (0.00054 X_3) where X_1 =Triceps skinfold, X_2 = Subscapular skinfold, X_3 = Abdominal skinfold

Body Fat Percentage was determined by the equation recommended by Siri (1956)

Body fat percentage = (4.57/Body density-4.142) x 100

Lean Body Mass was determined using the equation given by Ardle *et al*., (1986).

LBM = Body weight (kg) - [(Body fat percentage/100) x Body weight]

Mean values of body density, body fat percentage and lean body mass is represented in Table.4.25. Body fat percentage greater than 25 and 30 for boys and girls respectively indicates obesity (Williams *et al*., 1992).

Body density of boys varied between 0.85 to 0.89 and lean body mass from 22.73 to 32.22. Lean body mass tended to increase progressively with age in boys. But this trend was not seen in body density.

As far as body fat percentage is concerned boys of all the age groups (7 to 12 years) observed to have much less than 25 per cent body fat, which ranged between 10.82 to 15.01.

The body fat percentage of girls varied between 8.05 to 18.07. These values were also far less than the upper limit recommended (30%). Similar to boys, girls also showed a progressive increase in lean body mass with age. The mean values of lean body mass of American children belonging to 12 years of age were reported as 40.3 and 37.3 for boys and girls respectively (Chumlea *et al*., 2002). In the present study the mean value was found to be 32.22 and 32.56 for boys and girls respectively.

Table 4. 25. Mean values of body density, body fat percentage and lean body mass of the selected sample

Age (Years)	Boys (n=1190)			Girls (n=1810)		
	Body density	**Body fat percentage**	**Lean body mass**	**Body density**	**Body fat percentage**	**Lean body mass**
7	0.87	12.83	22.73	0.92	8.05	19.38
8	0.85	14.98	25.56	0.88	10.93	23.68
9	0.87	13.40	26.50	0.81	17.47	26.85
10	0.87	12.53	28.17	0.81	18.07	29.77
11	0.89	10.82	29.68	0.87	12.40	29.88
12	0.85	15.01	32.22	0.87	11.49	32.56

The body fat percentage and lean body mass of the sample according to gender is given in Figures 4. 10. and 4.11.

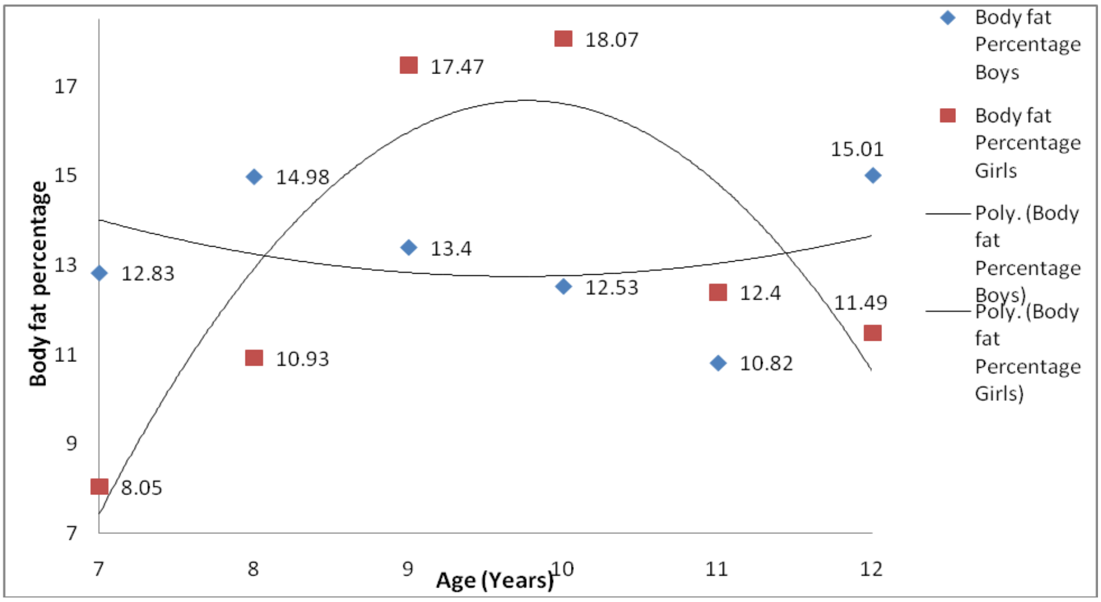

Figure 4. 10. Gender wise presentation of body fat percentage

Body fat percentage of girls tends to increase from 7 to 10 years and a decline was seen from 11 year onwards. In case of boys the body fat percentage increased from 7 to 8 and then a gradual decline was observed from 9 to 11 followed by a steep rise at 12 years.

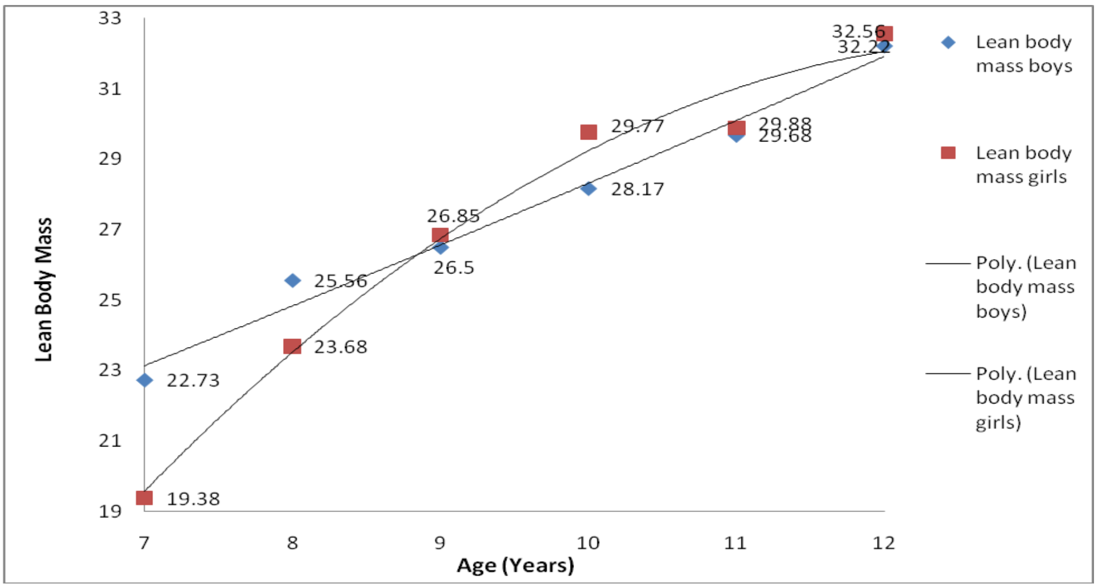

Figure 4. 11. Gender wise presentation of lean body mass

Girls had more amount of lean body mass than boys till the age of eight and after that boys had more amount lean body mass, with a corresponding increase in body fat percentage among girls up to 11 years. This may be due to reduction in physical activities among girls in pre pubertal period and increase in body fat as a part of pubertal growth. Increased sedentary activities among girls were also reported by Reilly *et al*. (2006).

To sum up girls were more malnourished than boys. There is a coexistence of under and over nutrition among school children which demands urgent attention. The overall prevalence of overweight and obesity in this study was found to be more than 9 per cent using reliable percentiles suitable for school children.

4. 2. General background

4. 2. 1. Socio-economic conditions

Social and environmental factors are associated with elevated body mass in children (Friedman *et al*., 2009). Hence an attempt was made to study this aspect and the details are furnished under the following heads:

- Family details : religion and family structure
- Educational status of the parents
- Occupational status of parents
- Monthly income
- Monthly expenditure
- Housing condition
- Availability of basic amenities

Family details: religion and family structure

Distribution of families based on religion, type of family and family size are presented in Table 4. 26.

Table 4. 26. Family details: religion and family structure

S. No.	**Details**	**Number of families (%)**
1	**Religion**	
	Hindus	1818 (60.60)
	General	1374 (75.74)
	SC / ST	444 (24.42)
	Christians	1050 (35.00)
	Muslims	132 (4.40)
	Total	**3000**
2	**Type of family**	
	Joint	1314 (43.80)
	Nuclear	1686 (56.20)
	Total	**3000**
3	**Family size** **Number of adults in family**	
	1 – 2	1686 (56.20)
	3 – 4	756 (25.20)
	5 - 6	528 (17.60)
	>7	30 (1.00)
	Total	**3000**

4	**Number of children in family**	
	Single child	154 (5.13)
	Two children	1862 (62.07)
	Three children	714 (23.80)
	Four children	222 (7.40)
	Five children	48 (1.60)
	Total	**3000**

Figures in parenthesis indicate percentage

Socio-economic details of the families are important factors having impact on the nutritional status of school children (Ghosh, 1997; Vijayalakshmi and Rao, 1988; Saxena, 1986). Table 4. 26. reveals that 60.60 per cent of the sample surveyed were Hindus, 35 per cent were Christians and 4.40 per cent were Muslims.

The Table further shows that majority of the families (56.20 per cent) followed nuclear family system, while 43.8 per cent followed joint family system. This revealed the recent social trend where there is fading of joint family system. This change is brought in by the social processes such as urbanisation which has ushered the spread of nuclear family system. Paul (2001), Panjikkaran (2001) and Devi (2000) in their studies in Kerala brought out the fact that most of the families in Kerala followed nuclear family system.

Majority of the families were small in size with two adults (56.20%) and two children (62.07%). This finding is in line with the observations made by National Nutrition Monitoring Bureau (NNMB, 1984) in Kerala which reported that; small family norm was getting high practice even among low income groups. The same trend was observed by Padikkal (2000) and Udaya (1996) in their studies conducted in Kerala.

Educational status of the parents

The information on educational qualification of the parents is shown in Table 4.27.

Table 4. 27. Educational status of parents

Educational status of parents	Father Number (%)	Mother Number (%)
Illiterate	18 (0.60)	12 (0.40)
Lower Primary school	300 (10.00)	324 (10.80)
Upper Primary school	900 (30.00)	912 (30.40)
High school	564 (18.80)	512 (17.07)
College	1218 (40.60)	1240 (41.33)
Total	**3000(1000)**	**3000(1000)**

Figures in parenthesis indicate percentage

Majority of the parents had college education including 40.6 per cent of father and 41.33 per cent of mother. This was followed by education up to upper primary level (30% each). Parental illiteracy was least common (less than 1%).

Mothers, in fact had an educational status at par or even more than fathers at all levels including the college education. Illiterate mothers were also less (0.4%) in number than fathers (0.6%). A positive association between parental literacy and nutritional status was reported by Devadas (1994). The female population having a better educational level, is very important, since the level of education of mothers, according to UNICEF (1991), influenced the nutritional status of children.

Occupational status of parents

Details regarding the occupational status of parents are shown in Table 4.28.

Table 4. 28. Occupational status of parents of the selected sample

Occupational status of parents	Father Number (%)	Mother Number (%)
Government job	720 (24.00)	270 (9.00)
Private job	984 (32.80)	882 (29.40)
Agriculture	84 (2.80)	30 (1.00)
Business	726 (24.20)	150 (5.00)
Coolie	474 (15.80)	318 (10.60)
Unemployed	12 (0.40)	1350 (45.00)
Total	**3000 (100)**	**3000 (100)**

Figures in parenthesis indicate percentage

Employment status of the father showed that majority (32.8%) were working in private sector. Doing small business (24.2%) or engaged in Government jobs (24%) were also there. 15.8 per cent were coolies whereas majority of the mothers (45 per cent) were unemployed and confined to household duties. Mothers working in private sector was 29.4 per cent and 10.6 per cent were coolies.

Monthly income

As the Table 4. 29. depicts, the monthly income of the families as reported by the respondents ranged between rupees 2000 to 30,000. Only 18.73 per cent of the families had an income of above Rs 20,000/month, whereas 7.8 per cent had only a meagre income of less than Rs 2000 / month.

Table 4. 29. Monthly income of the family

Monthly income (Rs.)	Number of families (%)
Up to 2000	54 (7.80)
2001 – 6000	800 (26.67)
6001 – 10,000	761 (25.37)
10,001 – 20,000	823 (27.43)
20,001 – 30,000	562 (18.73)
Total	**3000**

Figures in parenthesis indicate percentage

Majority of the families (52.04%) fell under the category of Rs 2001 to Rs 10,000 / month, followed by an income range of Rs 10,001 to 20,000 / month (27.43 %). According to the available reports (India economic survey, 2009) the per capita monthly income in Kerala is Rs 5250.

Monthly expenditure

The details regarding the expenditure pattern of the families as percentage of the monthly income is presented in table 4.30. Table reveals that food expenditure was the major expenditure in majority of families. It varied between 30 to 60 per cent of the monthly income. Next major expenditure was on education (up to 30 per cent of the family income), followed by clothing. The expenditure incurred on transport and entertainment was up to 20 per cent of the family income.

Table 4. 30 Monthly expenditure pattern of the families

Expenditure as percentage of monthly income	Percentage of families						
	Food	**Clothing**	**Shelter**	**Transport**	**Education**	**Entertainment**	**Health**
1 - 9	0.4	70.8	88.6	80.8	36.6	59.8	91.6
10 – 19	3.0	17.4	9.6	19.2	34.8	40.2	1
20 – 29	8.6	11.8	1.33	-	26.00	-	0.4
30 – 39	33	-	0.2	-	2.60	-	-
40 – 49	24.6	-	-	-	-	-	-
50 – 59	30.4	-	-	-	-	-	-

Housing condition

The housing conditions of the sample were enquired and are presented in Table 4.31.

Table 4. 31. Housing conditions of the samples

S.No	Parameter	Number of families (%)
1	**Ownership of house**	
	Own	2418 (80.6)
	Rented	582 (19.4)
2	**Number of rooms**	
	1 -2	012 (0.4)
	3 -5	2034 (67.8)
	6 - 8	954 (31.8)

3	**Type of roof**	
	Thatched	006 (0.2)
	Tiled	810 (27.0)
	Concrete	2184 (72.8)
4	**Separate rooms for children**	
	Yes	1206 (40.2)
	No	1794 (59.8)

Figures in the parenthesis indicate percentage

From Table 4. 31, it may be noted that 80.6 per cent of the families had their own house and the remaining 19.4 per cent were living in rented home. Regarding the number of rooms in the house 67.8 per cent of the families had 3 to 5 rooms. Only very few 0.4 per cent reported one to two rooms. Regarding roofing conditions, it was seen that RCC roof (72.8%) was more common than tiled (27%) or thatched roof (0.2%). It was also observed that 59.8 per cent of the houses had separate rooms for children of school going age.

Availability of basic amenities

Availability of other basic amenities in the families is presented in Table 4. 32. It was observed that 61.8 per cent of the families had their own well as the source of drinking water. The remaining 38.2 per cent depended on tap water for drinking purposes, which is supplied through co-operation. All the families had their own lavatory facilities (100%) and drainage facilities (100%). Almost all (99.8 per cent) had electricity connections at home. Majority of the families had more than one form of recreational facilities. Television was there in 99 per cent of the families, Computer and radio respectively were there in 48.4 per cent and 40.2 per cent of the families.

Table 4. 32. Availability of basic amenities in the family

S.No.	Particulars	Number of families (%)
1.	**Source of drinking water**	
	Own well	1854 (61.8)
	Tap	1146 (38.2)
2.	**Lavatory facilities**	
	Yes	3000 (100)
	No	0
3.	**Drainage facilities**	
	Present	3000 (100)
	Absent	0
4.	**Electricity**	
	Present	2994 (99.8)
	Absent	6 (0.2)
5.	**Recreational facilities**	
	Television	2970 (99)
	Computer	1452 (48.4)
	Radio	1206 (40.2)
	Newspaper	2388 (79.6)
6.	**Labour saving devices**	
	Yes	2989 (99.63)
	No	11 (0.37)

Figures in parenthesis indicate percentage

It was seen that 79.6 per cent of the families read news papers as a source of information. Labour saving devices such as mixie, washing machines and pressure cookers etc were present in 99.6 per cent of the families.

4. 2. 2. Personal profile of the sample

Details regarding the personal profile of the sample are discussed under the following heads.

- Age and gender wise distribution of the sample
- Mothers age at the birth of the sample
- Birth weight and birth order
- Breast feeding practices
- Physical activity pattern of school children
- Television / computer viewing habits
- Mode of transport to school
- Involvement in household duties
- Morbidity pattern
- Problems faced by obese/overweight children

Age and gender wise distribution of the sample

Three thousand school going children belonging to the age group of 7 to 12 years were screened to assess the extent of prevalence of obesity and overweight. Age and gender wise distribution of the sample (n=3000) is given in Table 4.33. Out of the total 3000 school children selected for study, 39.67 per cent were boys and the remaining 60.33 per cent were girls. Majority of girls were in the age group of 10 years (29.28%) followed by 9 years (22.65%), where as boys were mostly in the age group of 12 years (25.63%).

Table 4. 33. Age and gender wise distribution of the sample

Age (years)	Boys (n=1190)	Girls (n=1810)	Total (n=3000)
7	250 (21.01)	240 (13.26)	490 (16.33)
8	180 (15.13)	295 (16.30)	475 (15.83)
9	240 (20.17)	410 (22.65)	650 (21.67)
10	75 (6.30)	530 (29.28)	605 (20.17)
11	140 (11.76)	205 (11.33)	345 (11.50)
12	305 (25.63)	130 (7.18)	435 (14.5)
Total	**1190 (39.67)**	**1810 (60.33)**	**3000 (100)**

Figures in parenthesis indicate percentage

Mothers age at the birth of the sample

Several studies show that mother's age at the birth of the child has direct effect on the weight gain of child. The details in this regard were obtained and are presented in Table 4.34. Majority of mothers gave birth to children (who formed the sample population) between the age group of 20 to 25 years. The average age at marriage of women and child birth in Kerala is 20 years and 20 to 25 years respectively, in comparison with age 16 years in India. (Kerala Family Health Survey, 2009).

Table 4. 34. Mother's age at the birth of the subject

Age of delivery (Years)	Number and percentage of sample
18 - 20	138 (4.6)
20 - 22	762 (25.4)
23 - 25	1140 (38)
26 – 28	414 (13.8)
29 - 31	330 (11)
>31	216 (7.2)

Figures in parenthesis indicate percentage

Birth weight and birth order

Details regarding the birth weight and birth order of the sample was enquired from their parents to determine whether there is any relation between birth weight and overweight/obesity. The results are presented in Table 4.35. It is obtained from the Table 4.35. that only 8.4 per cent of children had low birth weight ie less than 2.5 kg (small-for-date babies). Majority (60.9%) of children reported to have birth weight between 2.5 to 3 kg. Weight, between 3 to 3.5 kg and more than 3.5 kg was seen among 27.6 and 2.8 children respectively. Birth order of the selected school going children is also presented in the same table. Among the sample population of school going children, majority (57.8%) reported to be of second position in the birth order followed by the first born (26.8%) and third born (15.4%).

Table 4. 35. Birth weight and birth order of the sample

S.No	Particulars	Number and percentage of sample
1	**Birth weight (kg)**	
	< 2.5	252 (8.4)
	2.5 – 2.8	909 (30.3)
	2.8 – 3	926 (30.9)
	3 – 3.5	829 (27.6)
	>3.5	84 (2.8)
2	**Birth order**	
	First	804 (26.8)
	Second	1734 (57.8)
	Third	462 (15.4)

Figures in parenthesis indicate percentage

Breast feeding practices

Table 4. 36. presents the breast feeding practices. Age of delivery and duration of breast feeding proved to have a positive correlation with body weight of children, hence details on these lines were collected. It was observed that majority (97.4%) of mothers breast fed their babies, and 46 per cent of mother's breast fed till 2 years and 3 per cent continued it even after the age of two. This shows that most of the mothers are aware of the advantage of breast feeding. Only very few 1.8 per cent and 8.6 per cent respectively breast fed their child for less than 3 months and 3 to 6 months respectively. The reasons given for not breast feeding the babies were

unavoidable situations like lack of breast milk, mother's employment in far away place and mother's ill health.

Table 4. 36. Breast feeding practices

Breast feeding practices	**Number (%)**
Yes	2922 (97.4)
No	78 (2.6)
Duration of breast feeding	
<3months	54 (1.8)
3-6 months	258 (8.6)
7– 12 months	1140 (38)
1 – 2years	1380 (46)
>2 years	90 (3)

Figures in parenthesis indicate percentage

Prolonged and exclusive breast feeding reduced the risk of being obese or overweight, among school age children (Procter and Holcomb, 2008; Li *et al*., 2008; Owen *et al*., 2005b; Harder *et al*., 2005; Li *et al*., 2003). This effect is more likely to be related to the composition of breast milk than to lifestyle factors (von Kries *et al*., 1999a). Duration of breast feeding during infancy was compared with the percentage of prevalence of overweight and obesity among school children and is presented in Table 4.37. The overweight and obese were identified using CDC percentiles.

Table 4. 37. Duration of breast feeding and incidence of Overweight/ obesity among the sample

Duration of breast feeding	Number and percentage of sample	Prevalence of	
		Overweight Number	**Obese Number**
Never breast fed	78 (2.6)	9 (11.53)	4 (5.13)
<3months	54 (1.8)	9 (16.67)	5 (9.26)
3-6 months	258 (8.6)	21 (8.14)	17 (6.59)
7– 12 months	1140 (38)	66 (5.78)	17 (1.49)
1 – 2years	1380 (46)	93 (6.73)	33 (2.39)
>2 years	90 (3)	2 (2.22)	4 (4.44)
Total	**3000**	**200**	**80**

Figures in parenthesis indicate percentage

This study reveals that only very few (2.6%) children were there in the category of never breast fed and 1.8 per cent was breast fed for less than 3 months. Never breast fed or very short period of breast feeding like less than three months put together contributed the maximum number of overweight (28.20%) and obesity (14.39%) among children. As the duration of breast feeding increased a progressive reduction in the incidence of overweight was seen, with the lowest prevalence (2.2%) among children who were breast fed for more than two years. Obesity prevalence was also found to reduce with increased duration of breast feeding during infancy. So the results clearly indicated the association between duration of breast feeding in infancy and incidence of overweight and obesity among school going age.

The results are supported by the study conducted by von Kries *et al*., (1999a) who found that the prevalence of obesity in children who had never been breast fed was 4.5 per cent (in the present study it was 5.13%) as compared to 2.8 per cent children who were breastfed. A clear dose response effect was identified for the duration of breast feeding on the prevalence of obesity: the prevalence was 3.8 per cent for 2 months of exclusive breast feeding, 2.3 per cent for 3 to 5 months, 1.7 per cent for 6 to 12 months, and 0.8 per cent for more than 12 months. Similar relations were found with the prevalence of being overweight.

It is plausible that breast feeding might indeed have a programming effect in preventing obesity or becoming overweight in later life. Lucas *et al*., (1981, 1980) found significantly higher plasma concentrations of insulin in infants who had been bottle fed than in infants who had been breast fed; these higher concentrations would be expected to stimulate fat deposition and the early development of adipocytes. Breast milk also contains bioactive factors which may modulate epidermal growth factor and tumour necrosis factor α, both of which are known to inhibit adipocyte differentiation in vitro (Hauner *et al*., 1995; Petruschke *et al*., 1994). The amount of energy metabolised and the protein intake of breastfed children is considerably lower than previously assumed and significantly below the intake of infants who are fed formulas (Whitehead, 1995; Heinig *et al*., 1993). In longitudinal studies (Deheeger *et al*., 1996; Cachera *et al*., 1996; Cachera *et al*., 1995) a significant relation was found between dietary protein intake at the age of 10 months and later body mass index and the distribution of body fat, suggesting that a high intake of protein in early childhood might increase the risk of obesity later. Indeed, in animal studies the availability of protein during foetal and postnatal development was found to have long term effects on the metabolic programming of glucose metabolism and body composition in adult life (Burns *et al*., 1997; Desai *et al*., 1997; Desai and Hales, 1997).

Physical activity pattern of school children

Lack of involvement in physical activities is considered to be a major reason for development of weight abnormalities among children. Hence the involvement of physical activities of the children was enquired and the results of the same are presented in Table 4. 38.

Table 4. 38. Physical activity pattern of school children

S.No.	Particulars	Boys	Girls	Total
1	**Participation in indoor/outdoor games**			
	Yes	1190 (100)	1810 (100)	3000
	No	0	0	(100)
2	**Time spent on sports and games at school**			
	< 1 hr/ day	390 (32.77)	409 (22.60)	831 (27.7)
	1hr – 2 hr/ day	300 (25.21)	504 (27.84)	804 (26.8)
	>2hrs/day	196 (16.47)	57 (3.15)	221 (7.37)
	< 1 hr/ week	212 (17.82)	500 (27.62)	712 (23.73)
	1hr – 2 hr/week	67 (5.63)	255 (14.09)	322 (10.73)
	>2hrs/week	25 (2.10)	85 (4.70)	110 (3.67)
	Total	**1190 (100)**	**1810 (100)**	**3000 (100)**

Figures in parenthesis indicate percentage

Physical education and participation were compulsory in all schools, so all the samples (100%) were engaged in physical activities like sports and games. But the duration varied. Majority of them (27.7%) spent less than one hour per day in play activities, followed by 1 to 2 hours (26.8%). Only 7.37 per cent of children reported that they used to play for more than 2 hrs per day. The rest of them were not in the habit of engaging regularly in play activities than girls. Among them quiet a good number (23.73 %) spent less than 1 hour / week. Gender wise analysis showed that boys were more regularly engaged in play activities than girls.

Television / computer viewing habits

Sedentary life style due to emergence of television and computers is considered to be a major reason for reduction in sports and game activities and development of overweight and obesity among children in developed countries. Hence television and computer viewing habits of school children were enquired and the details are presented in Table 4.39. The habit of watching TV was found to be very common (100%) among the sample. The duration mostly varied from less than one hour (66.6%) to one to two hours (33.26%). During holidays the children were found to spend more time for watching TV such as 1 to 2 hours (40.67%) or >2 hrs (35.10%). Similar trend was observed in both boys and girls. Regarding computer more boys than girls owned a computer although in the general population only 48.4 per cent had computer at home. On week days majority (59.78%) spent less than one hour with computer which increased to one to two hours (41.53%) or more than two hours (38.71%) on weekends or holidays. Girls in general were found to spent less time in computer than boys. Playing computer games was the most preferred item compared to browsing or similar activities.

Table 4. 39. Television/ computer viewing habits of school children

Sl. No.	Particulars	Boys (n=1190) %	Girls (n=1810) %	Total (n=3000) %
1	**Habit of watching television**			
	Yes	100	100	100
2	**Time spent on watching television**			
	Daily			
	<1 hrs	57.31	72.71	66.60
	1 – 2 hrs	42.69	27.07	33.26
	>2hrs	0	0.22	0.13
	Holidays			
	<1 hrs	27.39	21.99	24.14
	1 – 2 hrs	40.17	41.16	40.76
	>2hrs	32.44	36.85	35.10
3	**Having computers**			
	Yes	65.88	36.91	48.40
	No	34.12	63.09	51.6
4	**Time spent on computers**			
	Daily			
	<1 hrs	34.69	89.22	59.78
	1 – 2 hrs	44.01	5.83	26.44
	>2hrs	21.01	4.94	13.77

	Holidays			
	<1 hrs	11.10	29.94	19.77
	1 – 2 hrs	39.92	43.41	41.53
	>2hrs	48.98	26.65	38.71
5	**Preferred type of programmes**			
	Games	100	100	100
	Browsing net	6.38	2.10	4.41
	Others	7.40	2.99	5.37

Mode of transport to school

Table 4. 40. Mode of transport to school

S.No.	Particulars	Number and percentage of sample
1	**Mode of travel**	
	Walking	488 (16.27)
	Public transport	735 (24.5)
	Cycling	593 (19.76)
	Own car	601(20.03)
	Others (School bus, Tempo)	583 (19.43)
2	**Distance to travel**	
	<1/2 km	781 (26.03)
	½ - 1 km	300 (10)
	2 – 4 km	528 (17.6)
	>4 km	1391 (46.37)

Figures in parenthesis indicate percentage

Majority of children depended on vehicles such as public transport (24.5%), own car (20.03), cycling (19.76%) and school bus/ tempo for travelling to school (Table 4. 40). Walking and cycling supposed to be good exercise were used only by 16.27 and 19.76 per cent of the sample. Use of four-wheelers for travelling was seen among 64 per cent of children further projecting their sedentary life style.

Involvement in household duties

The involvement in household duties is yet another form of exercise to children. Data on this are given in Table.4.41.

Table 4. 41. Involvement of the sample in household activities

Particulars	**Boys**	**Girls**	**Total**
Washing clothes	35 (1.17)	89 (2.97)	124 (4.13)
Washing utensils	10 (0.33)	65 (2.17)	75 (2.5)
Sweeping	5 (0.17)	97 (3.23)	102 (3.4)
Gardening	97 (3.23)	99 (3.3)	196 (6.53)
Others (Purchasing of goods)	678 (22.6)	198 (6.6)	876 (29.2)

Figures in parenthesis indicate percentage

Involvement in household duties was observed only among a very small per cent of children, that too among girls. Boys in general were involved in purchasing of items from nearby shops.

Morbidity pattern

Morbidity pattern of school children for the last one year is presented in Table 4.42.

Table 4. 42. Morbidity pattern of school children

Particulars	Boys n=1190	Girls n= 1810	Total n=3000
Diarrhoea/ Vomiting	1190 (100)	1810 (100)	3000 (100)
Measles	12 (1.01)	7 (0.39)	19 (0.63)
Chicken pox	15 (1.26)	17 (0.57)	32 (1.07)
Mumps	12 (1.01)	10 (0.55)	22 (0.73)
Fever	1190 (100)	1810 (100)	3000 (100)
Jaundice	3 (0.25)	2 (0.11)	5 (0.17)
Respiratory diseases	45 (3.78)	34 (1.13)	79 (2.63)
Others (cardiovascular diseases, tuberculosis, kidney diseases etc.)	8 (0.67)	10 (0.55)	18 (0.60)

Figures in parenthesis indicate percentage

Occurrence of illnesses during the previous one year period was enquired with the parents of the school children. All of them (100%) reported having fever and diarrhoea/ vomiting very often. Among other diseases, respiratory problems like asthma were the major one affecting a good number of boys and girls (2.63%). Urinary infections and mild heart disease such as tachycardia were also reported among children (0.6%).

In general, the rate of morbidity was found to be slightly more among boys than girl children.

Problems faced by obese/ overweight children

The psycho social problems of obese and overweight children were obtained and the results are given in Table 4.43.

Among the population studied teasing or bullying (86%) by peers and others and the resultant low body image (75%) were the most prominent ones. Bias and stereotyping by teachers and even by parents (21%) was also noticed. The situations gradually lead these children to develop low self-esteem (48%) and depression (12%).

The outcomes duly reflected on the incompetence in terms of physical (18%) as well as academic achievements (16%). Some studies have linked childhood obesity with poorer quality of life, low self esteem, depression, and poor academic achievement within childhood and adolescence (Power *et al*., 2003; Goodman and Whitaker, 2002; Wright *et al*., 2001; Gortmaker *et al*., 1993).

Table 4. 43. Psychosocial problems faced by obese and overweight children

S.No	**Psychosocial consequences**	**Obese/ Overweight (n = 100)**	
		Yes	**No**
1	Low self esteem	48 (48)	52 (52)
2	Depression	12 (12)	88 (88)
3	Poor body image	75 (75)	25 (25)
4	Stigmatization and discrimination by peers	6 (6)	94 (94)
5	Targets of teasing or bullying	86 (86)	14 (14)
6	Bias and stereotyping by teachers	21 (21)	79 (79)
7	Athletic incompetence	18 (18)	82 (82)
8	Poor academic achievement	16 (16)	84 (84)

Figures in parenthesis indicate percentage

There are also evidences to prove that obesity limited to childhood has little impact on socioeconomic, educational, social, and psychological outcomes in adult life (Viner and Cole, 2005; Hesketh *et al.*, 2004). Characterisation of obese children in negative ways such as least preferred by friends and more likely to be the targets of teasing or bullying had also been reported by Vlierberghe *et al*., (2009), Reilly *et al*., (2005) and Lobstein *et al*., (2004). Among the overweight children, appearance-related teasing was more prevalent, frequent, and upsetting, involved disparaging nicknames focusing more on weight rather than less stigmatized aspects of appearance, and more often perpetrated by peers in general rather than a specific peer (Hayden-wade *et al*., 2005). Nearly all children are teased, but some may have a higher likelihood of being the targets of chronic teasing; the experience is often quite painful (Shapiro *et al*., 1991) and psychologically traumatic for some (Slee, 1995). Verhulst *et al*., (2008) have reported Sleep-disordered breathing and systemic inflammation in overweight children.

As seen in the present study, bias and stereotyping by teachers and even by parents were also reported by Puhl and Latner, (2007). The poor body image reported by a huge portion (75%) of the sample, and the poor physical performance especially in athletic field both are in line with the findings of Flodmark (2005) and Wardle and Cooke (2005), who observed that obese community samples have low body satisfaction and physical self-competence than non-obese and few are depressed or have low global self esteem.

4. 3. Dietary Practices

4.3.1. Food habits and meal pattern

Food habits and meal pattern of the families having a direct impact on the BMI status of children were obtained and are presented in Table 4.44.

Table 4. 44. Food habits and meal pattern of the families of the selected samples

Sl. No	Food habit	Number of children (%)
1	Vegetarian	223 (7.43)
2	Non vegetarian	2777(92.57)
	Meal pattern	
1	Two meals	676 (22.53)
2	Three meals	2324 (77.47)

Figures in parenthesis indicate percentage

Majority (92.5 per cent) of the families surveyed were non vegetarians. Only 7.43 per cent of families were found to be pure vegetarians. Three meal pattern was more common (77.47%) among the families followed by two meals / day (22.53%). None of them found to follow single meal pattern. The results clearly indicated the popularity of non vegetarianism among the sample population. As high as 79 per cent of Indian families has at least one non-vegetarian member and in Kerala it is 98 per cent (Yadav and Kumar, 2006). The fact that almost a quarter (22.53%) of the families had only two square meals a day is projective of their low income and poor purchasing power.

4. 3. 2. Food expenditure pattern

Budget allocation for food may vary from family to family and this decision is influenced by a variety of factors which keep changing in the individual families. Per capita food availability and family food security are well associated with this family food budget. Hence an attempt was made to study the food expenditure pattern of the family and the frequency of use of various food items by the family.

Distribution of families based on their monthly food expenditure pattern as per cent of food budget is presented in Table 4.45.

Major portion of the food expenditure was incurred on cereals. 71 per cent of the families spent 50 to 60 per cent for the purchase of cereals. Next preferred items were fish, meat and egg. Nearly 62 per cent of the families allotted 30 to 40 per cent of their food budget on fish. Expenditure on meat by majority of the families (73%) was 20 to 30 per cent and egg, 30 per cent by 95 per cent of families. Whereas expenditure on pulses was only less than 10 per cent of food budget by majority (54%). So also other vegetables (59%), GLV (70%) and root vegetables (82%).

It was surprising to note that 30 per cent of the families did not spent any money on leafy vegetables. In general less than10 per cent of the food expenditure was allocated to pulses, roots and tubers, green leafy vegetables and other vegetables respectively by 54 per cent, 82 per cent, 70 per cent and 59 per cent of families. Hence it can be inferred that, the expenditure on cereals was found to be the highest (50-60%) among the families whereas expenditure on pulses (54%), other vegetables (59%), green leafy vegetables (70%) and roots and tubers (82%) by majority of the families was as low as 10 per cent or less. Meat (54%) and milk (52%) accounted for 20 per cent of the food expenditure and egg (95%) accounted for 30 per cent of the food expenditure. Also it was surprising to note that 94% of the families spent less than 10 per cent for the purchase of fruits. So, next to cereals, the major items for food expenditure was non vegetarian foods like fish (30-40%) and meat (20-30%) and less than 10 per cent expenditure on all the protective foods like pulses, green leafy vegetables and fruits. This observation is in line with the findings of Planning Commission, Government of India (2008a).

Table 4. 45. Food expenditure pattern of families of the selected samples (n==3000)

Food items	Percentage expenditure							
	Nil	**<10**	**20**	**30**	**40**	**50**	**60**	**70**
Cereals	0.00	0.00	1.00	4.00	15.00	34.33	36.67	9.00
Pulses	0.00	54.00	24.00	22.00	0.00	0.00	0.00	0.00
Other vegetables	0.00	59.00	0.00	32.00	0.00	9.00	0.00	0.00
Green leafy vegetables	30.00	70.00	0.00	0.00	0.00	0.00	0.00	0.00
Roots and tubers	0.00	82.00	18.00	0.00	0.00	0.00	0.00	0.00
Meat	5.00	22.00	54.00	19.00	0.00	0.00	0.00	0.00
Fish	3.00	5.00	30.00	30.00	32.00	0.00	0.00	0.00
Egg	1.00	0.00	0.00	95.00	4.00	0.00	0.00	0.00
Fruits	0.00	94.00	6.00	0.00	0.00	0.00	0.00	0.00
Milk	8.00	20.00	52.00	20.00	0.00	0.00	0.00	0.00

4. 3. 3. Frequency of consumption of foods

Cereals, fats and oil and sugar and jaggery were the items used on daily basis by all the families (100%). As it comes to protective foods, pulses were used twice a week by the majority (35%) and green leafy vegetables mostly on occasional basis (62%). Other vegetables formed part of the diet either daily (37.2%) or very frequently *ie.* four times a week (31.2%) by majority, whereas fruit was consumed mostly (27%) twice in a week. Fish was the more frequently used (2 to 4 times in a week) than meat (1 to 3 times a week).

Hence it can be stated that green leafy vegetables was the least represented item in the meal followed by pulses and fruits. Studies by Planning Commission (2008b) also support these findings.

Frequency of use of ready to cook food items by the family is given in Table 4.47. Majority of the families never purchased instant foods like idli mix (85 per cent), dosa mix (85 per cent), noodles (68.4 per cent), ice cream mix (97 per cent) and gulab jamun mix (98.8 per cent).Occasional purchase was noted with respect to noodles (31.6%), idli and dosa mix (15% each).

Table 4. 48. reveals frequency of use of ready to eat food items by the families. Occasional use of baked products like bread (96.13%) and cakes (97.17%); fried items like samosa or puffs (98.10%) and chips (93.4%); carbonated beverages like cola / pepsi (93.33%) and soft drinks like ready to serve drinks (95.5%), squash (74.53%) was reported by majority of families. Jams (93%), pickles (54.14%) and ketch ups (48.33%) were also found to be the delicacies. Consumption of biscuits once or twice a week was seen among 37.90 per cent of the families.

Table 4. 46. Frequency of consumption of foods

Food items	Frequency of use (Percentage of families)					
	Daily	W_4	W_3	W_2	W_1	Occasionally	Never
Cereals	100	0.00	0.00	0.00	0.00	0.00	0.00
Pulses	11.00	25.00	26.80	35.00	2.20	0.00	0.00
Green leafy vegetables	0.00	0.00	0.40	15.60	22.00	62.00	0.00
Roots and tubers	6.00	24.80	29.60	25.20	12.00	2.40	0.00
Other vegetables	37.20	31.20	29.80	1.80	0.00	0.00	0.00
Fruits	13.00	20.00	18.20	27.00	11.80	10.00	0.00
Milk and milk products	44.40	24.80	15.20	3.60	4.40	7.60	0.00
Meat	0.00	0.00	20.40	15.80	26.80	32.00	5.00
Fish	4.80	22.60	24.40	26.60	13.60	3.00	5.00
Egg	4.80	0.00	26.80	15.00	27.20	30.00	1.00
Fats and oils	100	0.00	0.00	0.00	0.00	0.00	0.00
Sugar and jaggery	100	0.00	0.00	0.00	0.00	0.00	0.00

W4 – Four times in a week, W3 – Three times in a week, W2 – Twice in a week, W1 – Once in a week

Table 4. 47. Frequency of use of ready to cook food items by the family

Food items	Occasionally	Never
Idli mix	450 (15)	2550 (85)
Dosa mix	450 (15)	2550 (85)
Noodles	948 (31.6)	2052 (68.4)
Ice cream mix	30 (3)	2910 (97)
Gulab jamun mix	36 (1.2)	2964 (98.8)

Figures in parenthesis indicate percentage

Table 4. 48. Frequency of use of ready to eat food items

Food items	Weekly once/twice	Occasionally	Never
Baked products			
Bread	3.87	96.13	0.00
Cakes	2.83	97.17	0.00
Biscuits	37.90	62.10	0.00
Fried items			
Chips	6.60	93.40	0.00
Samosa / Puffs/ Cutlets	1.90	98.10	0.00
Concentrated items			
Coca cola/ Pepsi/ Carbonated beverages	0.00	93.33	6.67
Ready To Serve drinks (Maaza, Frooti etc)	0.00	95.5	4.5
Squash/ Syrup/ Crush	0.00	74.53	25.47
Jams	0.00	93.00	7.00
Jellies	0.00	1.80	98.20
Pickles	45.86	54.14	0.00
Sauces / Ketch ups	0.00	48.33	51.67

Total omission of vegetables and fruits in any form and also the dairy products clearly indicated the trend of avoiding protective foods in the dietaries of school children.

4. 3. 4. Eating behaviour of school going children

Details regarding the eating habits of children were enquired and the results are furnished in Table 4.49.

Table 4. 49. Details regarding eating habits of school children

Sl. No.	Particulars	(%)
1	**Meals**	
	Regular breakfast	67.13
	Skipping breakfast	32.87
	Regular lunch	100
	Home lunch	8.17
	Packed lunch	91.83
2	**Snacking**	
	Yes	95.83
	No	4.17
3	**Raw salads**	
	Yes	34.1
	No	65.9
4	**Snacking while watching television**	
	Yes	76.67
	No	23.33

5	**Snacks preferred**	
	Fried items	85.13
	Biscuits	81.17
	Cakes	75.00
6	**Fixed meal time schedule**	
	Yes	15.2
	No	84.8
7	**Taking meals with family members**	
	Yes	25.4
	No	74.6

Eating behaviour is yet another factor found to influence the food consumption pattern and thereby the nutritional profile of a person. Since skipping breakfast is common among school aged children and adolescents, the habit of taking breakfast by the children was studied. It was seen that 67.13 per cent only had the habit of taking breakfast and the remaining 32.87 per cent more often skipped their breakfast almost every day mainly to reach school in time. Some of those (20.41%) who skipped breakfast at home used to have it from schools. But all of them used to take lunch daily, mostly in the form of rice, chapathi or any other breakfast items.

The habit of taking snacks was observed in 95.83 per cent sample. Most preferred snacks being fried items (85.13%), biscuits (81.17%) and cakes (75%) either homemade or purchased from bakeries. Crisping during watching television is a major reason for development of obesity in industrialised countries. It was seen that our country is also getting accustomed to that culture. In this study it was seen that 76.67 per cent had the habit of eating something while watching television.

Consumption of raw foods as salads or fruits was seen only in 34.1 per cent of children. Majority (84.8 per cent) did not keep a specific time schedule, for taking food. It was also reported that due to the busy time schedule and preoccupations, majority (74.6%) never found time to take meals along with family members. The detail on the habit of taking food outside by the sample is given in Table 4.50.

Table 4. 50. Distribution of sample based on the habit of eating outside

Sl. No.	Particulars	No. of children (n= 3000)	Percentage
1	Preference for eating outside	3000	100
2	Preference for food items		
	Non vegetarian	2413	80.43
	Vegetarian	587	19.57
3	Preference for food outlet		
	Hotels	1432	47.73
	Fast food centres	3000	100
	Bakery / Cafeteria	1875	62.5
4	Frequency of fast food intake		
	Daily	86	2.87
	Weekly	321	10.7
	Monthly	2523	84.1
	Rarely	70	2.33

All the children (100%) had the habit of taking food from outside, out of which only 19.57 preferred to have only vegetarian foods while the remaining 80.43 per cent preferred non-vegetarian foods. Major source of such foods, as reported by them included fast food centres (100%), bakeries (62.5%) and hotels (47.73%). Regarding the frequency of eating outside, it was observed that majority (84.1%) had food from outside every month, followed by weekly dine out (10.7%). The habit of taking food from outside everyday was also observed among 2.87 per cent of sample. The fast food preferences by the sample was also studied and given in Table 4.51.

Table 4. 51. Fast foods commonly consumed by school children

Items	Percentage
Fruit juices	100
Puffs	89.27
Samosa	84.77
Paratha	78.53
Milk shakes	78.03
Cutlets	76.7
Chips	69.67
Chicken preparations	66.23
Carbonated beverages	47.73
Biriyani	41.43
Fish preparations	32.9
Egg preparations	28.53
Noodles	1.43

Increased availability and use of fast foods are a major reason for increased prevalence of obesity in children (Crawford *et al*., 2008). The trend observed from the above table was that majority of them preferred high fat and energy dense foods such as puffs (89.27%), samosa (84.7%), paratha (78.53%), cutlets (76.7%) and chips (69.67%). Fruit based beverages and carbonated beverages were also preferred by children. Similar results were observed in the study conducted by Panjikkaran (2001) and Paul (2001).

4. 3. 5. Food consumption pattern of the sample

Food Intake

Mean food intake of obese, overweight and normal weight children was found out on a sub sample of 150 children (50 each from the three groups) selected at random. The distribution of obese, overweight and normal weight was done on the basis of BMI percentile values suggested by CDC (2000).

Table 4.52 present the mean food intake of obese, overweight and normal children (7 to 9 years boys) in comparison with the RDA. Comparison of mean food intake of normal weight, over weight and obese children (7-9 years, Boys) is given in Figure 4.12. and its percentage adequacy with RDA is depicted in Figure 4.13.

The food intake by boys as obtained from the table, indicated a progressive increase of cereal intake with BMI status. It ranged from a significantly lower intake ($p<0.01$) of 78.6% of RDA by normal weight children to higher intake (not statistically significant) by overweight (104.5%) and obese children (136.4%). Similarly the intake of sugar and jaggery was also found to be higher than RDA among obese boys (116.7%).

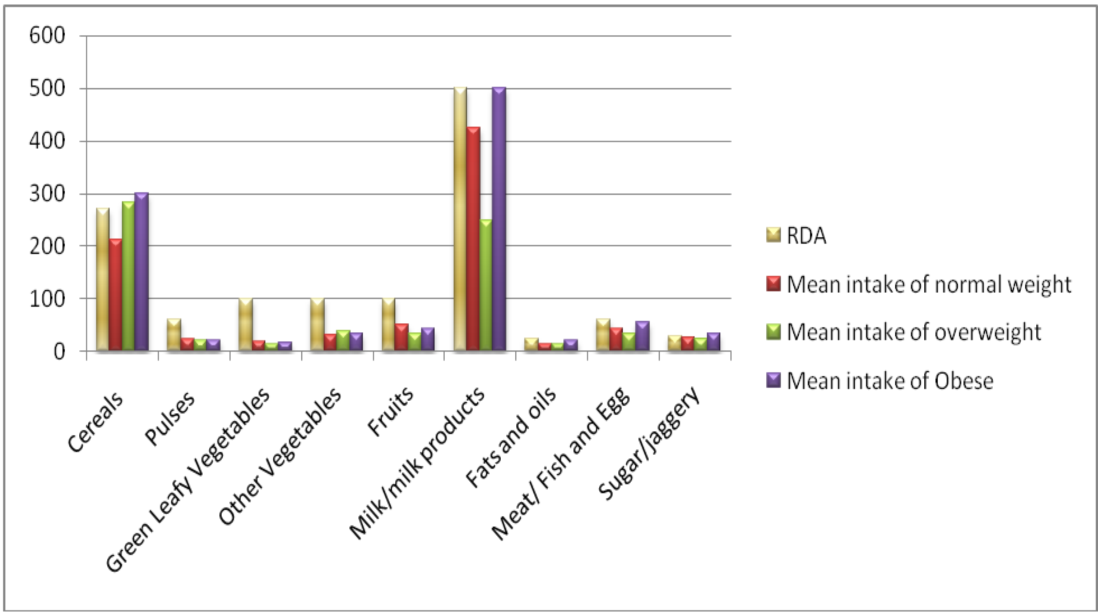

Figure 4. 12. Comparison of mean food intake of normal weight, over weight and obese children (7-9 years, Boys) with RDA

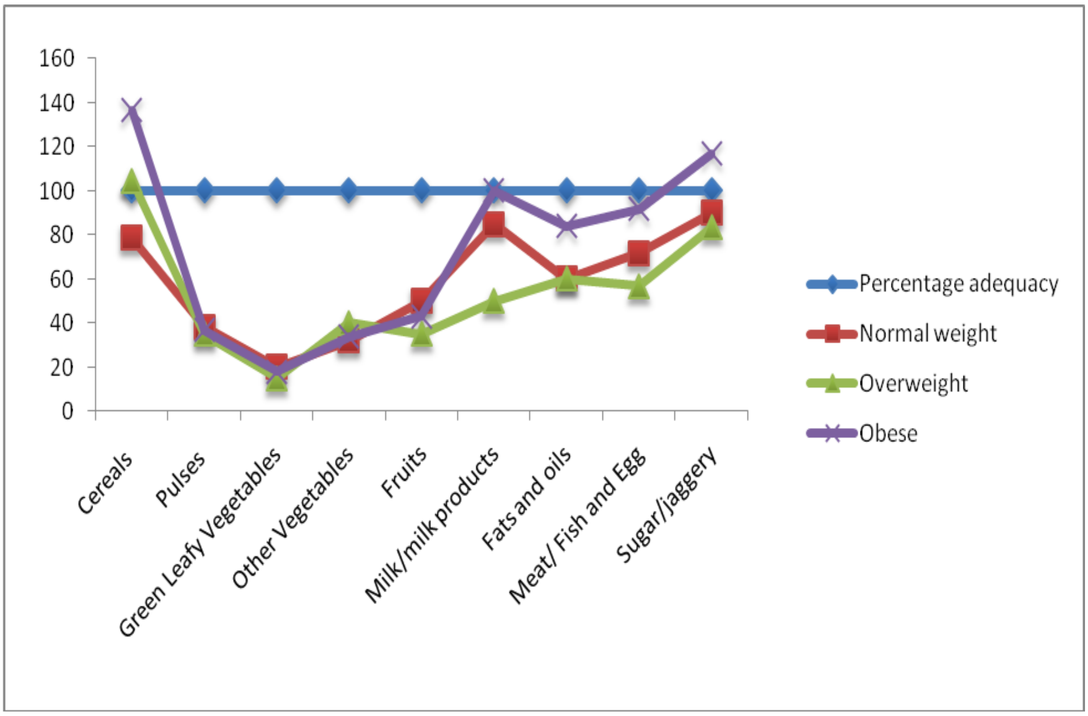

Figure **4. 13.** Comparison of percentage adequacy of mean food intake of normal weight, over weight and obese children (7-9 years, Boys)

Meat and fish intake infact showed a significant deficit ($p<0.01$) among normal and overweight children but obese children had a intake of 91.7% of RDA and was not significant statistically. Similar trend was seen in the intake of fats and oils and milk and milk products. At the same time, the protective foods like pulses, vegetables, GLV and fruits showed highly significant deficit ($p<0.01$) irrespective of BMI status.

The Table 4. 53. and Figure 4.14. presenting the mean food intake of girls of 7 to 9 years also brought out very clearly in the grave deficit ($p<0.01$) on all kinds of protective foods like pulses, vegetables, GLV and fruits irrespective of BMI status.

Figure 4.15 presents the percentage adequacy of mean food intake of normal weight, over weight and obese children (7-9 years, Girls). Cereal intake also followed the same trend as in boys, such as deficit (73.3%) at a significant level ($p<0.05$) among normal weight children and a surplus intake (104.4%) which was not statistically significant by obese girls. Fats and oils, unlike in case of boys, showed a shortage and ranged between 80.8 per cent to 88.0 per cent, which was found to be statistically significant. The same trend was observed with the intake of sugar and jaggery.

In short it may be stated that gender difference was not observed in the intake of cereals. It was significantly deficient among normal weight and a surplus intake (statistically insignificant) among obese boys and girls. Intake of protective foods was significantly lower than the RDA in both the groups. Milk and dairy products, sugar and jaggery showed a distinctive difference in the consumption with a highest intake among obese children.

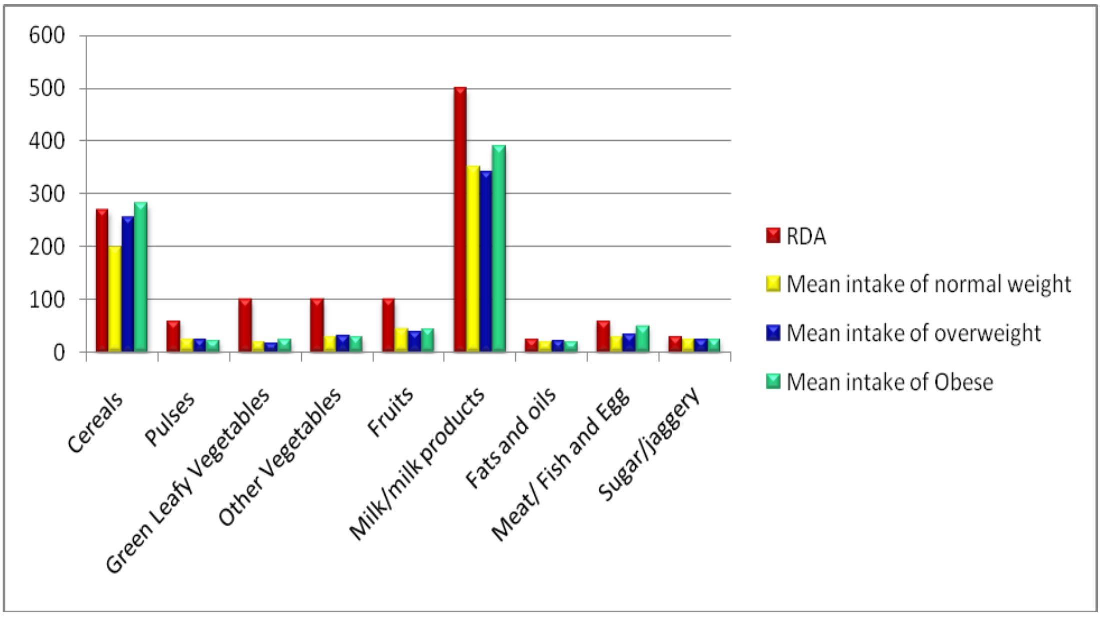

Figure 4. 14. Comparison of mean food intake of normal weight, over weight and obese school children (7-9 years, Girls) with RDA

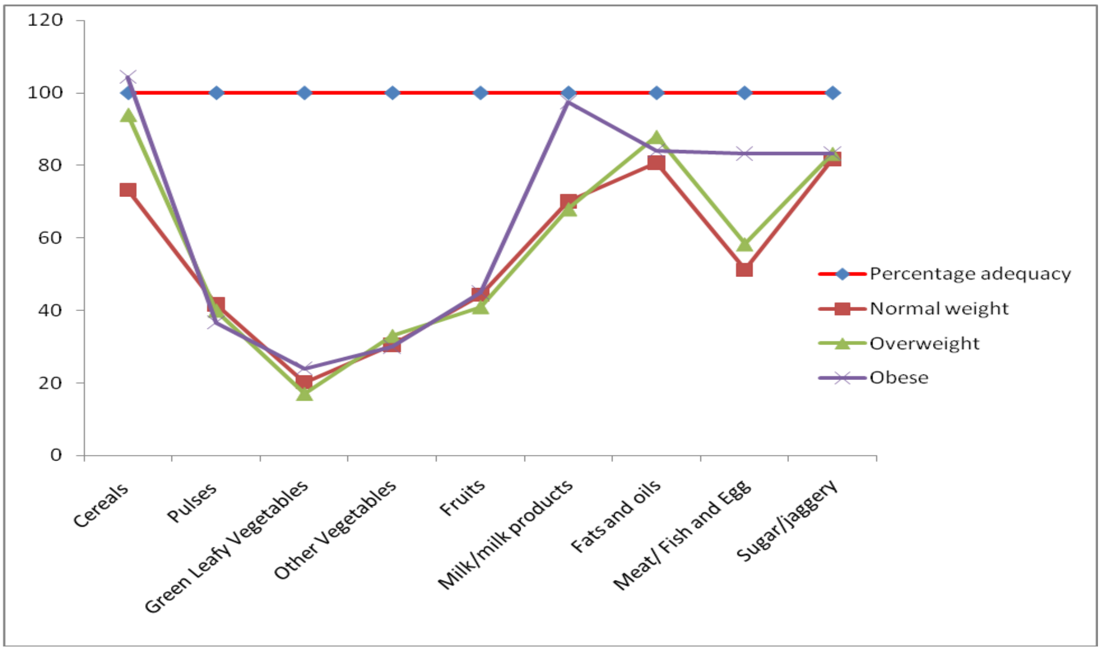

Figure **4. 15.** Comparison of percentage adequacy of mean food intake of normal weight, over weight and obese children (7-9 years, Girls)

Table 4. 52. Mean food intake of normal weight, over weight and obese children (7-9 years, Boys)

Food groups	RDA (g/d)	Normal			Overweight			Obese		
		Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA
Cereals	270	212.22±29.8	4.13**	78.6	282±15.80	1.71^{NS}	104.5	300±32	2.21^{NS}	136.4
Pulses	60	23.4±6.69	12.28**	38.3	21 ±2.7	15.54**	35	22±3.0	10.87**	36.7
Green leafy vegetables	100	19±2.50	34.81**	19	15± 3.2	37.89**	15	18±3.6	31.10**	18
Other vegetables	100	32±3.00	15.71**	32	40±2.5	22.77**	40	34±6.0	27.00**	34
Fruits	100	50±4.75	8.56**	50	35±4.0	13.40**	35	43±5.6	8.86**	43
Milk and milk products	500	423.8±27.9	6.11**	85	250±22.3	18.19**	50	500±23	0.31^{NS}	100
Fats and oils	25	15±5.00	4.5**	60	15±2.3	6.11**	60	21±4.5	0.96^{NS}	84
Meat, fish and egg	60	43± 5.20	6.18**	71.7	34±3.5	8.38**	56.7	55±5.2	0.81^{NS}	91.7
Sugar and Jaggery	30	27 ±8.39	0.801^{NS}	90	25±4.5	0.91^{NS}	83.3	35±6.7	1.12^{NS}	116.7

ICMR (1998) * Significant at 5 per cent level, ** Significant at 1 per cent level

Table 4. 53. Comparison of mean food intake of normal weight, over weight and obese children (7-9 years, Girls)

Food groups	RDA (g/d)	Normal			Overweight			Obese		
		Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA
Cereals	270	198.2±7.95	4.51*	73.3	254±45	1.24^{NS}	94.1	282±45	0.716^{NS}	104.4
Pulses	60	25.4±12.54	6.18**	41.7	24±7.5	5.97**	40	22±10	6.63**	36.7
Green leafy vegetables	100	20.2±5.6	6.18**	20.2	17±10.5	7.92**	17	24±7.5	5.97**	24
Other vegetables	100	30.5±6.5	7.26**	30.5	33±8.0	6.11**	33	30±6.11	6.03**	30
Fruits	100	44.3±15.0	5.12**	44.3	41±12.5	6.03**	41	45±10.62	5.31**	45
Milk and milk products	500	350.7±46.5	7.21**	70.1	340±47	5.13**	68	390±33	7.65**	97.5
Fats and oils	25	20.2±1.1	2.55^{NS}	80.8	22±6.5	1.88^{NS}	88	21±4.5	1.93^{NS}	84
Meat, fish and egg	60	30.7±15.47	4.54**	51.2	35±5.0	4.78**	58.3	50±5.5	1.55^{NS}	83.3
Sugar and Jaggery	30	24.5±6.0	2.25^{NS}	81.7	25±7.5	2.39^{NS}	83.3	25±5.0	2.16^{NS}	83.3

ICMR (1998)   *Significant at 5 per cent level, ** Significant at 1 per cent level

These findings clearly brought out the role of dietary factors on the incidence of obesity among children of the age group of 7 to 9 years. The school children in general, were found to be at equal risk of having a low fibre and micro nutrient deficient diet. Obese and overweight children were exposed to the double risk of low fibre and poor micronutrient diet along with high fat energy-dense foods.

The mean food intake of school children in the age group of 10 to 12 years (Boys) is given in Table 4.54 and Figure 4.16. The comparison of percentage adequacy with food intake is illustrated in Figure 4.17.

As the table and figure depicts the cereal intake by boys was significantly lower than RDA among the normal group, wheras the intake eventhough lower than RDA, failed to show any statistical significance for overweight and obese children. Fats and oils, flesh foods and egg and sugar and jaggery did not show any significant deviation from RDA in all the three groups. A high intake (116.7% of RDA) for non vegetarian items like meat, fish and egg were seen among overweight and obese children. But irrespective of BMI status all the children showed inadequacies in the intake of pulses , green leafy vegetables and fruits with statistical significance at 1% level for all the three groups. The food intake of (10-12 years) girls is presented in Table 4.55. and Figure 4.18. The comparison of percentage adequacy with food intake of 10 to 12 years girls is illustrated in Figure 4.19. The food intake by girls, indicated a progressive increase of cereal intake with BMI status. It ranged from a significantly lower intake ($p<0.05$) of 75.9 per cent of RDA by normal weight children to a intake of 98.4% by overweight (not statistically significant) and a higher intake of 107.8% by obese children. A significantly lower intake ($p<0.01$) of green leafy vegetables was observed in all the three groups. An intake of sugar and jaggery equivalent to RDA (not statistically significant) was observed among obese girls, whereas the intake was 85.7 % of RDA for both normal weight and overweight children. A compiled table on percentage adequacy of food intake by the sample is represented in Table 4. 56.

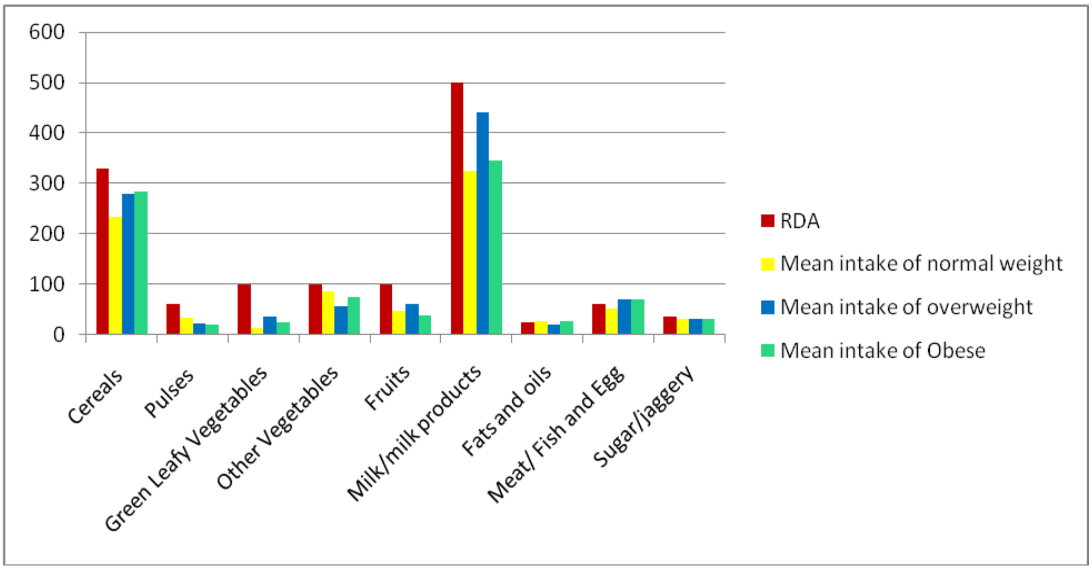

Figure 4. 16. Comparison of mean food intake of normal weight, over weight and obese school children (10-12 years, Boys) with RDA

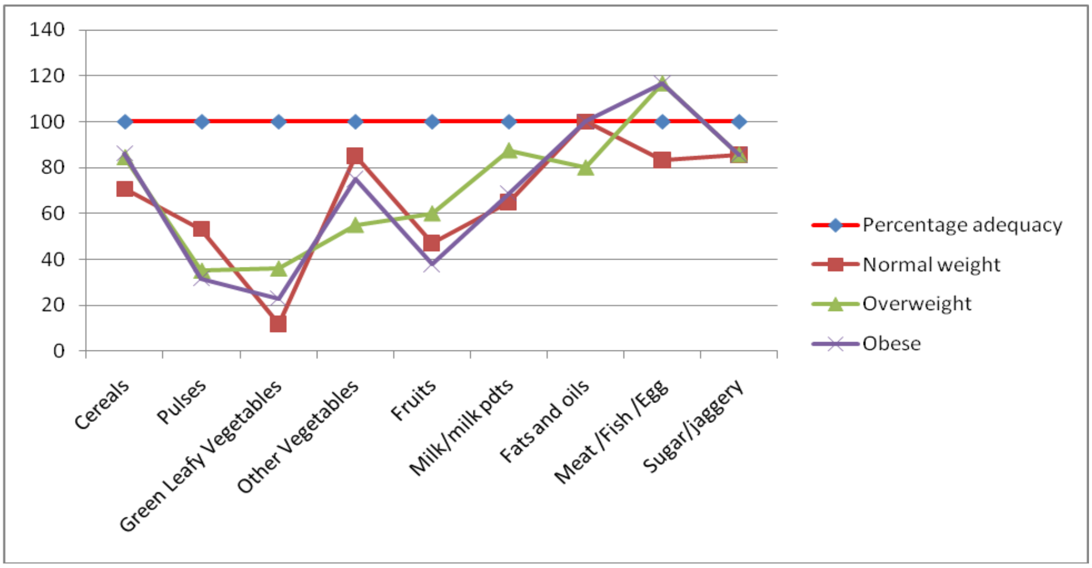

Figure 4. 17. Comparison of percentage adequacy of mean food intake of normal weight, over weight and obese children (10 – 12 years, Boys)

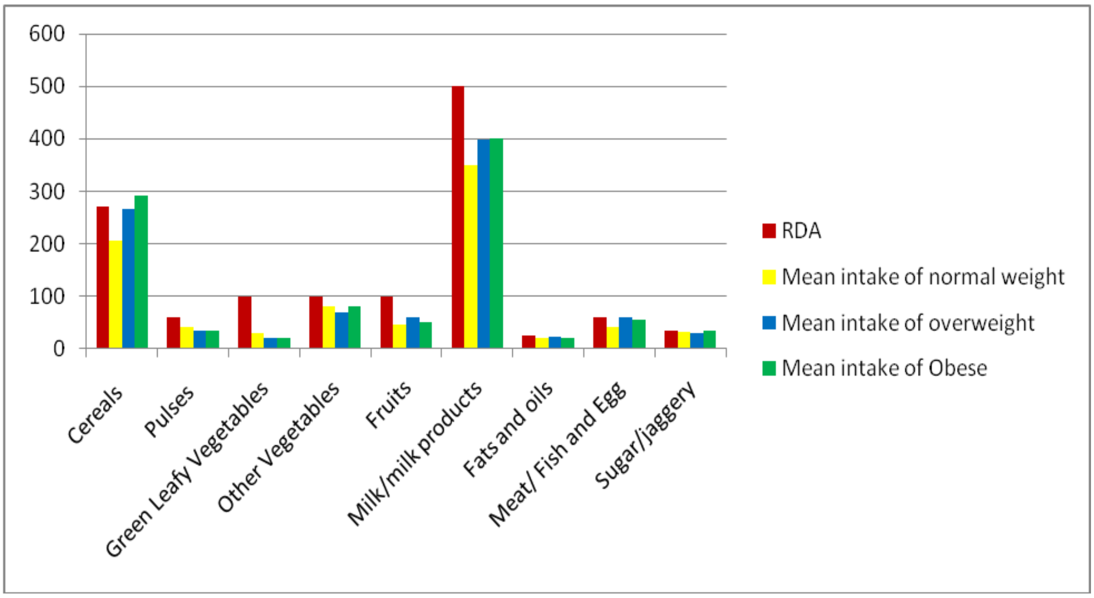

Figure 4. 18. Comparison of mean food intake of normal weight, over weight and obese school children (10-12 years, Girls) with RDA

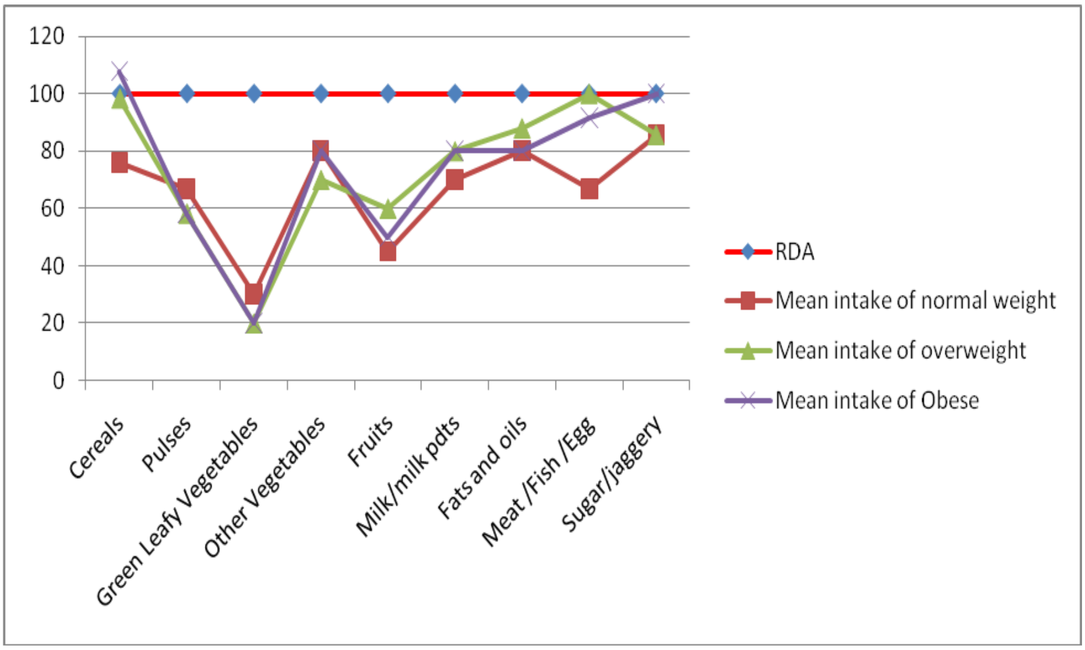

Figure 4. 19. Comparison of percentage adequacy of mean food intake of normal weight, over weight and obese children (10 – 12 years, Girls)

Table 4. 54. Mean food intake of normal weight, over weight and obese children (10 - 12 years, Boys)

Food groups	RDA (g/d)	Normal			Overweight			Obese		
		Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA
Cereals	330	233.2 ±40.22	5.39**	70.7	278.4±60.78	1.88^{NS}	84.5	284.46±31.5	1.57^{NS}	86.2
Pulses	60	32.3 ±7.31	8.57**	53.3	21±8.5	9.39**	35.0	19.3±2.5	12.4**	31.7
Green leafy vegetables	100	12.2±6.72	29.32**	12.0	36±12.3	8.30**	36.0	23.1±4.5	9.11**	23.0
Other vegetables	100	85.3±16.41	2.04^{NS}	85.0	55±13.1	5.16**	55.0	75.0±15.6	3.59*	75.0
Fruits	100	47.2±27.36	4.33*	47.0	60 ±15.7	4.78**	60.0	38.2±4.5	6.82**	38.0
Milk and milk products	500	325.4±52.13	7.51**	65.0	440 ±56.5	3.61*	87.5	344.5±27.5	5.59**	68.8
Fats and oils	25	25.4±10.96	0.10^{NS}	100.0	20±4.5	0.85^{NS}	80.0	25.4±6.5	0.13^{NS}	100
Meat, fish and egg	60	50.6±15.2	1.47^{NS}	83.3	70±6.5	1.34^{NS}	116.7	70±8.0	1.06^{NS}	116.7
Sugar and Jaggery	35	30.0±10.65	1.05^{NS}	85.7	30±6.5	0.766^{NS}	85.7	30±5.5	0.81^{NS}	85.7

ICMR (1998) * Significant at 5 per cent level, ** Significant at 1 per cent level

Table 4. 55. Comparison of mean food intake of normal weight, over weight and obese children (10 - 12 years, Girls)

Food groups	RDA (g/d)	Normal			Overweight			Obese		
		Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA	Mean (g/d)	t-value	% of RDA
Cereals	270	205.4±33.11	4.39*	75.9	265.70±35.3	0.32NS	98.4	291±25.5	0.93NS	107.8
Pulses	60	40.4±13.2	3.39*	66.7	35±10.5	0.83NS	58.3	35±15	4.65**	58.3
Green leafy vegetables	100	30.2±10.82	14.48**	30	20±15	16.11**	20	20±10.5	19.14**	20
Other vegetables	100	80.0±13.69	3.27*	80	70±15	4.44*	70	80±13	2.80*	80
Fruits	100	44.8±14.34	8.59**	45	60±10	4.60*	60	50±6.5	5.11**	50
Milk and milk products	500	350.8±48.5	7.23**	70	399.4±42.08	5.32**	80	400±50	4.83**	80
Fats and oils	25	20.4±6.23	1.79NS	80	22±5.5	1.34NS	88	20±4.5	1.7NS	80
Meat, fish and egg	60	40.5±9.91	4.51*	66.7	60±15.5	0.38NS	100	55±15	2.77*	91.7
Sugar and Jaggery	35	30.8±10.28	1.08NS	85.7	30±5.5	1.63NS	85.7	35±5	0.45NS	100

ICMR (1998) * Significant at 5 per cent level, ** Significant at 1 per cent level

Table 4. 56. Percentage adequacy of food intake by the sample

Food group	Boys						Girls					
	7 – 9 years			10 – 12 years			7 – 9 years			10 – 12 years		
	N	OW	O	N	OW	O	N	OW	O	N	OW	O
Cereals	78.6	104.5	136.4	70.7	84.5	86.2	73.3	94.1	104.4	75.9	98.4	107.8
Pulses	38.3	35	36.7	53.3	35.0	31.7	41.7	40	36.7	66.7	58.3	58.3
Green leafy vegetables	19	15	18	12.0	36.0	23.0	20.2	17	24	30	20	20
Other vegetables	32	40	34	85.0	55.0	75.0	30.5	33	30	80	70	80
Fruits	50	35	43	47.0	60.0	38.0	44.3	41	45	45	60	50
Milk and milk products	85	50	100	65.0	87.5	68.8	70.1	68	97.5	70	80	80
Fats and oils	60	60	84	100.0	80.0	100	80.8	88	84	80	88	80
Meat, fish and egg	71.7	56.7	91.7	83.3	116.7	116.7	51.2	58.3	83.3	66.7	100	91.7
Sugar and Jaggery	90	83.3	116.7	85.7	85.7	85.7	81.7	83.3	83.3	85.7	85.7	100

N – Normal weight, OW – Overweight, O - Obese

Thus it may be stated that school children of both the age groups (7 to 9 years and 10 to 12 years) exhibited the tendency of consuming more cereals which progressively increased with BMI status. Intake of more than 80 per cent of RDA was observed among obese children with regard to the consumption of energy dense foods such as fats, flesh foods / eggs and sugar and jaggery in both the age groups (7 to 9 years and 10 to 12 years).

These observations clearly predicted the dietary contributions to overweight and obesity among school children. At the same time a progressive reduction of pulses and vegetable consumption with the increase of BMI status and a thoroughly inadequate intake of green leafy vegetables (12% to 36% of RDA) and fruits (38% to 60% of RDA) invariably seen which indicates lack of protein rich and protective foods in the diet of the sample population (7 to 9 year and 10 to12 year old children).

Nutrient Intake

From the recorded food intake, the nutrient intake of children was calculated and compared with RDA given by ICMR, (2009).

Nutrient intake plays a crucial role in the development of obesity (Weker, 2006). The nutrient intake of 7 to 9 years boys and girls is presented in Table 4.57. and Table 4.58. respectively. Comparison of percentage adequacy of mean nutrient intake of normal weight, over weight and obese school children (7-9 years, Boys and Girls) is presented in Figures 4.20. and 4.21.

A progressive increase in energy intake from normal to obese children of 7 to 9 year age group (boys) was noticed. The surplus energy intake by obese boys was also found to be less statistically significant. Similar increasing trend from 70%

of RDA among normal weight to 100.3% of RDA among obese children was observed in the case of fat intake too.

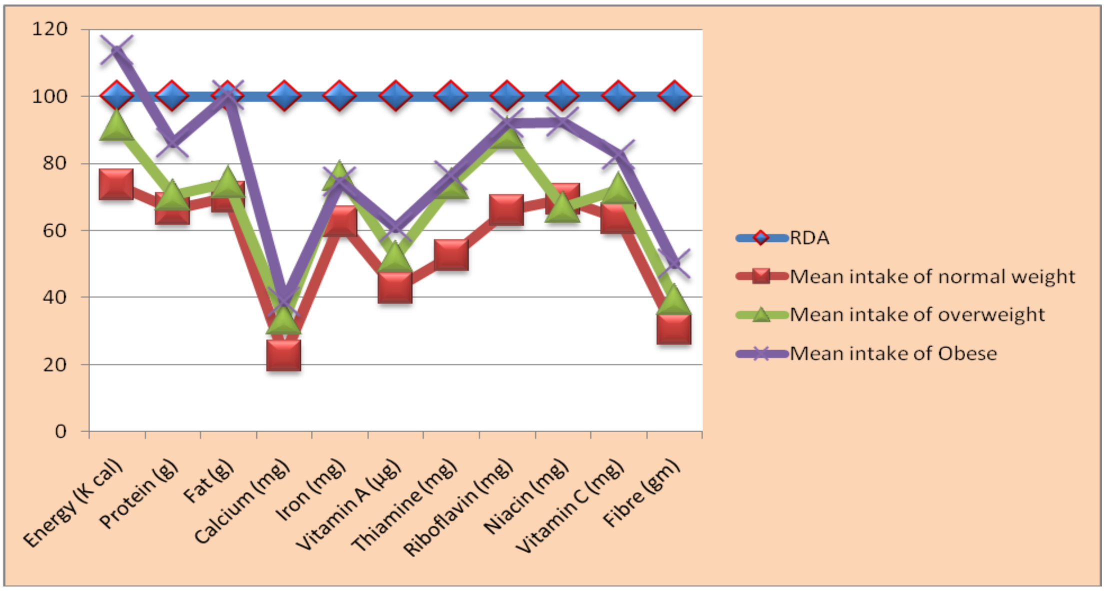

Figure 4. 20. Comparison of percentage adequacy of mean nutrient intake of normal weight, over weight and obese school children (7-9 years, Boys)

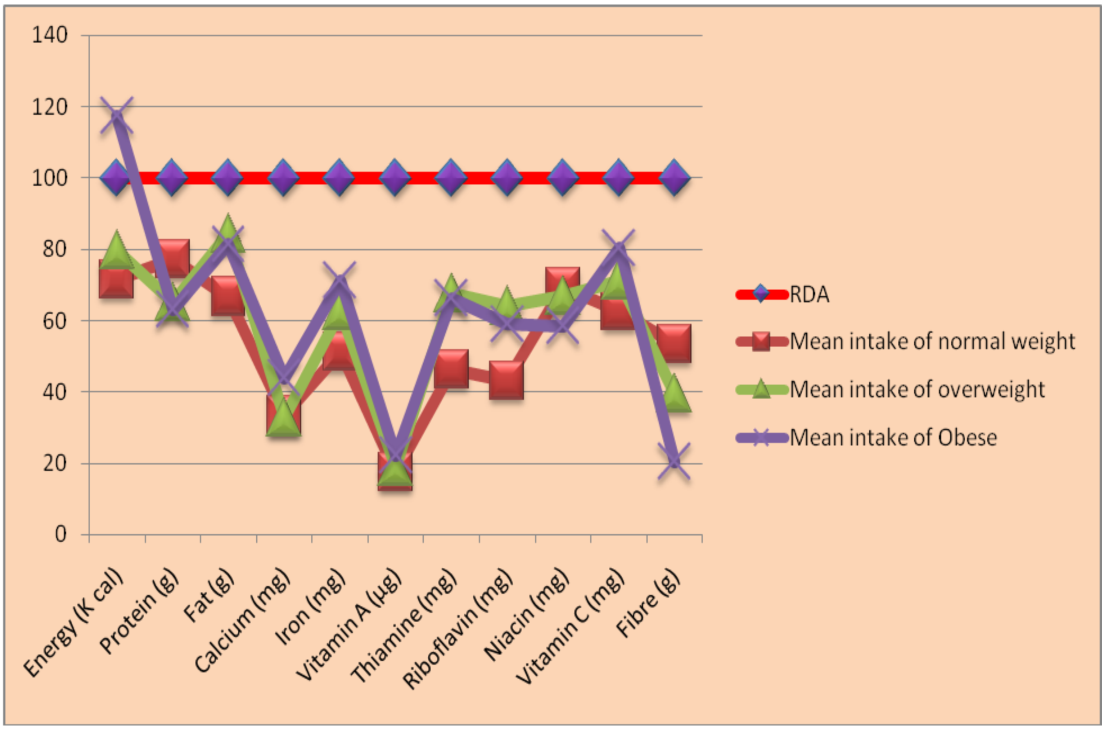

Figure 4. 21. Comparison of percentage adequacy of mean nutrient intake of normal weight, over weight and obese school children (7-9 years, Girls)

Table 4. 57. Mean nutrient intake of normal weight, over weight and obese school children (7-9 years,Boys)

Nutrients	**RDA***	**Normal**			**Overweight**			**Obese**		
		Mean±SD (g/d)	**t-value**	**% of RDA**	**Mean±SD (g/d)**	**t-value**	**% of RDA**	**Mean±SD (g/d)**	**t-value**	**% of RDA**
Energy (K cal)	1690	1245.8±136.86	7.28**	73.6	1546.6±110.5	1.32^{NS}	91.4	1921.2±167.5	4.68*	113.67
Protein (g)	29.5	19.6±7.12	3.11*	66.4	20.8±6.88	4.00*	70.5	25.4±6.01	2.23^{NS}	86.1
Fat (g)	30	21.0±6.32	3.18*	70.0	22.3±3.88	2.94*	74.3	30.1±2.74	0.34^{NS}	100.3
Calcium (mg)	600	136.2±45.53	22.82**	22.7	201.0±33.7	19.3**	33.5	232.0±38.9	20.6**	38.7
Iron (mg)	16	10.4±5.13	2.62^{NS}	62.5	12.2±3.11	1.66^{NS}	76.2	11.9±4.51	1.40^{NS}	74.4
Retinol (µg)	600	256.5±55.16	13.97**	42.75	312.7±47.3	6.12**	52.1	365.4±60.3	4.81**	60.8
Thiamine (mg)	0.8	0.42±0.15	5.68**	52.5	0.59±0.23	4.56*	73.8	0.61±0.22	2.97*	76.25
Riboflavin (mg)	1.0	0.66±0.16	4.59*	66.0	0.89±0.28	1.88^{NS}	89.0	0.92±0.30	1.28^{NS}	92
Niacin (mg)	13	8.94±2.69	3.33*	69.23	8.7±2.47	3.86*	66.9	12.0±3.44	0.85^{NS}	92.3
Vitamin C (mg)	40	25.4±6.10	5.50**	63.5	29.0±5.10	4.83**	72.5	33.0±4.23	3.68*	82.5
Fibre (g)	22	6.75±6.10	9.78**	30.6	8.66±7.50	6.12**	39.4	11±7.50	5.02**	50

ICMR (2009) * Significant at 5 per cent level, ** Significant at 1 per cent level

Table 4. 58. Mean nutrient intake of normal weight, over weight and obese school children (7-9 years,Girls)

Nutrients	RDA*	Normal			Overweight			Obese		
		Mean±SD (g/d)	t-value	% of RDA	Mean±SD (g/d)	t-value	% of RDA	Mean±SD (g/d)	t-value	% of RDA
Energy (K cal)	1690	1210.8±153.6	6.93**	71.6	1346.2±128.6	4.88**	79.6	1985.4±162.4	3.11*	117.4
Protein (g)	29.5	22.8±4.11	3.65*	77.3	19.2±2.76	5.08**	65.1	18.6±1.66	5.32**	63.1
Fat (g)	30	20.0±5.17	3.46*	66.7	25.3±4.97	2.12^{NS}	84.3	24.4±4.33	2.56^{NS}	81.3
Calcium (mg)	600	201.5±41.8	22.7**	33.6	196.4±33.7	25.9**	32.73	262.8±41.1	16.3**	43.8
Iron (mg)	16	8.2±3.67	4.87**	51.3	10.0±3.38	3.66*	62.5	11.4±4.00	2.73*	71.25
Retinol(µg)	600	105.4±21.36	48.5**	17.57	113.4±21.7	39.7**	18.9	133.3±31.9	33.7**	22.2
Thiamine (mg)	0.8	0.37±0.11	6.17**	46.25	0.54±0.23	4.52*	67.5	0.53±0.22	3.18*	66.25
Riboflavin (mg)	1.0	0.43±0.28	8.33**	43.0	0.64±0.37	4.16*	64.0	0.59±0.27	4.80**	59.0
Niacin (mg)	13	9.0±2.74	2.87*	69.23	8.7±3.02	3.11*	66.9	7.6±2.89	4.74**	58.5
Vitamin C (mg)	40	25.6±6.68	4.99**	62.5	28.5.0±5.93	4.71**	71.3	32.1±7.44	3.68*	80.3
Fibre (g)	22	11.75±3.10	6.58**	53.4	8.67±7.50	6.12**	39.4	10.23±7.50	4.53**	20.46

ICMR (2009)   * Significant at 5 per cent level, ** Significant at 1 per cent level

Intake of protein also followed the same upward trend. The intake was significantly lower than the RDA among normal weight ($p<0.05$) and overweight ($p<0.05$) children and not to any significant extent to obese group. Calcium, retinol, vitamin C and fibre content of the children's diet were totally inadequate.

Hence a significantly higher energy intake and a comparatively higher intake of fat and protein along with a low fibre diet were the root cause of obesity among boys.

For girls the energy intake was slightly lower than boys indicating a significant deficit ($p<0.01$) among normal weight and overweight group, but here also the obese girls had surplus energy intake which is also significant at 5 per cent level. Protein intake was inadequate irrespective of BMI status. Fat intake found to reduce with increase of BMI. But differences in fat intake by overweight and obese girls were not to any significant extent.

So far as girls (7 – 9 years) are concerned fat intake and the resultant intake of energy and low fibre intake was the cause of obesity. Iron deficiency was yet another feature noticed here. Unlike boys (where the deficit was not statistically significant) girls presented a significantly lowered intake than RDA in all the three groups studied, normal ($p<0.01$), overweight ($p<0.05$) and obese ($p<0.05$). But in the case of calcium, retinol and vitamin C extreme inadequacies were reported irrespective of gender in all the three categories.

Mean nutrient intake of normal, overweight and obese boys and girls of 10-12 years were compared with the actual intake and the results are furnished in Table 4.59, 4.60 and Figure 4.22 and 4.23. As it came to 10 to 12 year age group energy intake seemed to increase with BMI status among both boys (91.30% to 107.26%) and girls (87.91% to 115.47%).

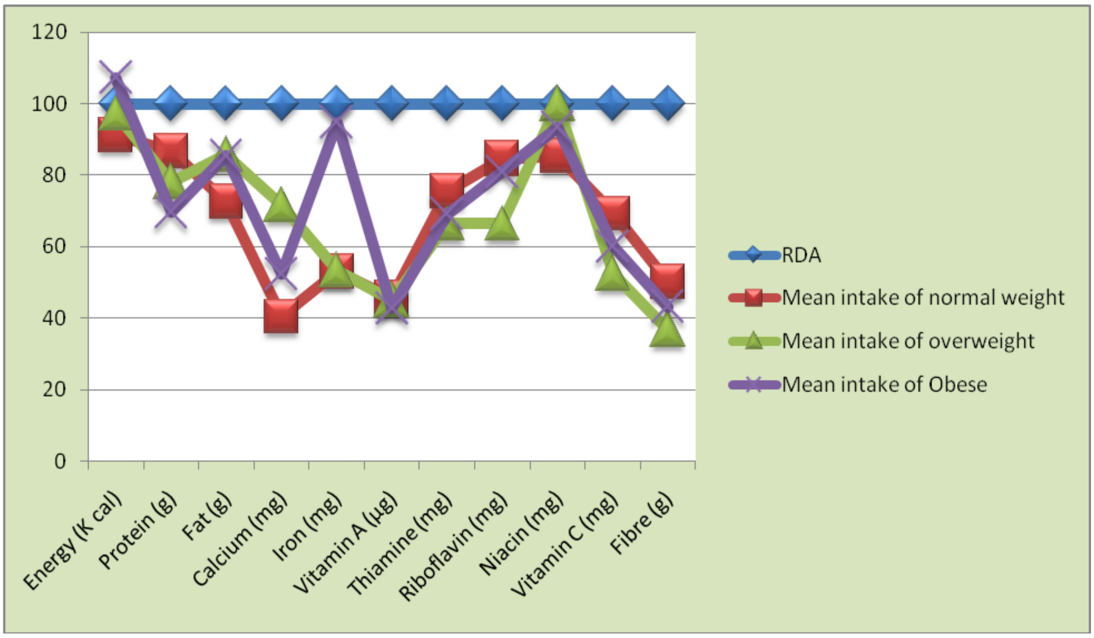

Figure 4. 22. Comparison of percentage adequacy of normal weight, over weight and obese school children (10 - 12 years, Boys)

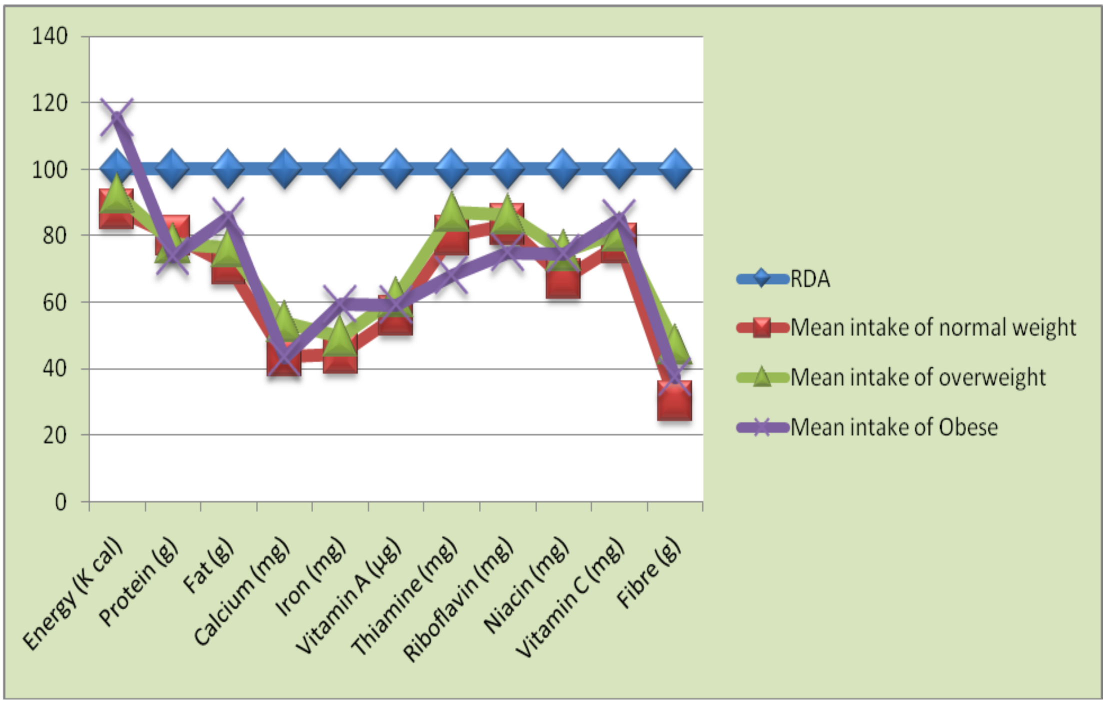

Figure 4. 23. Comparison of percentage adequacy of normal weight, over weight and obese school children (10 - 12 years, Girls)

Also energy intake by the girls of obese group (115.47% of RDA) was higher than that of boys (107.26% of RDA). Protein inadequacy followed the same trend among boys and girls indicating a significant deficit at all the three BMI status. Fat intake found to reduce with increase of BMI.

Iron deficiency with a significantly lower intake of iron among girls was continued to exist in the 10 to 12 year also. The significant difference ($p<0.01$) in calcium, retinol intake was uniformly seen irrespective of gender. Vitamin C intake was comparatively more among girls (77.5% to 85%) than boys (52.5% to 69.25%). Yet another feature was the reduction in the intake of vitamin C by the male population with the increase in BMI status clearly depicts the lack of fruits and vegetables in their diet. B complex vitamins like thiamine, riboflavin, niacin did not show much difference in their adequacy with gender.

Several studies have also shown the higher intake of fats and calories as the major contributing factor for the development of obesity among children. Crawford *et al*. (1995) and Kimm *et al*. (1996) show that African-American girls had lower intakes of calcium and potassium and higher intakes of vitamins, fat, and calories. Dietary variety of sweets, snacks, condiments, and carbohydrates is positively associated with body fatness whereas variety from vegetables was negatively associated with obesity in the studies conducted by Goran (2001) and Megan *et al*. (1999). To sum up, a higher intake of calorie dense foods rich in fat and energy and low fibre food contributes to weight gain. High intake of fat and calories by obese children from Kerala has been reported by Ramachandran (2004).

Table 4. 59. Mean nutrient intake of normal weight, over weight and obese school children (10 - 12 years, Boys)

Nutrients	RDA (g/d)	Normal			Overweight			Obese		
		Mean (g/d)	**t-value**	**% of RDA**	**Mean (g/d)**	**t-value**	**% of RDA**	**Mean (g/d)**	**t-value**	**% of RDA**
Energy (K cal)	2190	1999.4±137.88	3.09*	91.30	2128.8±186.4	2.27^{NS}	97.17	2349.0±216.6	2.64^{NS}	107.26
Protein (g)	39.9	34.6±6.68	4.43*	86.72	31.2±5.59	5.15**	78.20	27.8±5.00	6.68**	69.67
Fat (g)	35	25.4±3.11	4.92**	72.57	30.2±4.96	2.90*	85.71	29.9±3.88	3.37*	85.42
Calcium (mg)	800	323.5±57.6	25.7**	40.42	427.4±38.88	22.66**	71.67	314.8±55.7	26.6**	52.33
Iron (mg)	21	18.3±5.32	3.63*	52.94	13.0±3.86	5.16**	53.38	19.9±4.65	0.87^{NS}	94.76
Retinol (µg)	600	273.5±25.31	49.6**	45.58	271.8±35.91	39.78**	45.17	256.0±42.76	51.5**	42.67
Thiamine (mg)	1.1	0.83±0.13	4.57*	75.45	0.73±0.12	4.80**	66.36	0.76±0.16	4.67*	69.09
Riboflavin (mg)	1.3	1.1±0.23	2.84*	84.62	0.9±0.18	3.98*	66.36	0.89±0.2	4.20*	80.9
Niacin (mg)	15	12.8±4.04	3.67*	85.33	15.4±5.16	0.45^{NS}	100	14.6±4.88	0.76^{NS}	93.33
Vitamin C (mg)	40	27.7±7.01	4.82**	69.25	21.0±4.14	9.14**	52.5	24.8±5.56	6.58**	60.0
Fibre (g)	28.5	14.3±3.21	5.06**	50.17	10.5±4.14	8.53**	36.8	12.3±5.34	7.36**	43.2

ICMR (2009) * Significant at 5 per cent level, ** Significant at 1 per cent level

Table 4. 60. Mean nutrient intake of normal weight, over weight and obese school children (10 – 12 years, Girls)

Nutrients	RDA (g/d)	Normal			Overweight			Obese		
		Mean (g/d)	**t-value**	**% of RDA**	**Mean (g/d)**	**t-value**	**% of RDA**	**Mean (g/d)**	**t-value**	**% of RDA**
Energy (K cal)	2010	1767.6±151.00	3.60*	87.91	1862.2±174.98	2.68^{NS}	92.64	2321.0±216.80	2.56^{NS}	115.47
Protein (g)	40.4	32.3±4.94	3.67*	79.95	31.3±5.22	3.88*	77.48	29.8±4.15	4.89**	73.76
Fat (g)	35	25.4±6.54	3.42*	71.43	26.7±5.65	3.11*	76.29	30.2±6.86	2.54^{NS}	85.71
Calcium (mg)	800	349.6±76.77	13.13**	43.75	432±63.83	6.17**	54	346.8±56.9	15.77**	43.25
Iron (mg)	27	12.2±4.76	7.05**	44.44	13.4±3.82	5.88**	49.63	16.8±5.10	3.89*	59.26
Retinol (µg)	600	335.2±42.04	14.08**	55.95	367.9±51.66	10.94**	61.32	354.7±41.77	13.94**	59.12
Thiamine (mg)	1.0	0.8±0.13	2.97*	80	0.87±0.19	2.13^{NS}	87	0.68±0.12	4.56*	68
Riboflavin (mg)	1.2	1.0±0.21	2.19^{NS}	83.33	0.95±0.26	2.86*	86.36	0.90±0.16	3.13*	75
Niacin (mg)	13	8.7±2.83	3.40*	66.92	9.8±3.11	2.76*	75.38	9.7±3.88	2.96*	74.62
Vitamin C (mg)	40	31.2±4.97	4.05*	77.5	32.4±5.22	3.81*	81	34.4±5.75	2.53^{NS}	85
Fibre (g)	26.1	7.9±4.97	5.83**	30.3	12.3±2.83	4.56**	47.1	9.8±6.89	4.78**	37.5

ICMR (2009)   * Significant at 5 per cent level, ** Significant at 1 per cent level

4. 4. Clinical picture

Clinical examination is an important technique for assessing the nutritional status of a community. It gives direct information on the signs and symptoms prevalent (Jelliffe, 1966); (Kamath, 1986). Clinical examination was done on a subsample of 150 children (50 each of normal weight, overweight and obese children) with the help of a qualified physician and results are furnished in the table below.

Table 4.61. Clinical symptoms prevalent among the sample

Sl. No.	Symptoms	Normal weight (n = 50)	Overweight (n=50)	Obese (n=50)
1	Lack of lustre of hair	7 (14)	2 (4)	-
2	Thinness and sparseness	6 (12)	4 (8)	-
3	Dyspigmentation	3 (6)	1(2)	-
4	Diffuse depigmentation of face	6 (12)	1 (2)	-
5	Pale eyes	12 (24)	4 (8)	-
6	Angular scars	1 (2)	-	-
7	Teeth decay	5 (10)	7 (14)	6 (12)
8	Thyroid enlargement	2 (4)	-	-
9	Eczema	4 (8)	3 (6)	1 (2)
10	Asthma	4 (8)	3 (6)	6 (12)
11	Urinary infections	3 (6)	4 (8)	-

Figures in parenthesis indicates percentage

Clinical manifestations of nutritional deficiencies were totally absent among the obese children. Also, comparatively less number of overweight children had any signs of nutritional deficiency. Most of the deficiency signs were observed among the normal weight children. Among the nutritional disorders observed, paleness of eyes due to anaemia was the most prominent one. 24 per cent of normal weight children had this symptom. Protein deficiency in the form of lack of lustre (14%) and thinness and sparseness of hair (12%), diffuse depigmentation (12%) and dyspigmentation (6%) were also observed among normal weight category. The same trend, but to a lesser extent was noticed among the overweight children.

As far as the obese group is concerned, other morbidities like asthma (12%) and tooth decay were more common. The dental carries was also observed in normal weight (10%) as well as overweight children (14%), so also eczema of skin. This skin problem was found to reduce with increase of BMI status. Thyroid enlargement was yet another notable problem among normal weight children (4%). High incidence of dental carries and anaemia among adolescents in Kerala was also reported by Panjikkaran (2001), Suman (2000) and Paul (1993).

Similarly coexistence of childhood obesity and asthma has been reported by CDC (1997) and Troiano *et al*. (1995) and are exacerbated by factors in the modern-built-environment. According to CDC (1997) asthma is the most common chronic childhood disease occurring in approximately 54 of every 1000 children. From 1980 through 1996, childhood asthma increased dramatically, by approximately 5 per cent annually (CDC, 1998; 1996).

4. 5. Bio chemical parameters

Biochemical parameters were assessed on a subsample of 100 school children comprising of 50 children of normal weight and 50 from both obese and overweight category.

4. 5. 1. Blood lipid profile

4. 5. 2. Blood haemoglobin content and Blood pressure levels

4. 5. 3. Bivariate correlation between biochemical parameters and obesity

4. 5. 4. Correlation between blood lipid profile and BMI

4.5. 5. Correlation between blood pressure and BMI

4.5. 6. Formulation of a predictive index for overweight/obesity based on the biochemical parameters

4. 5. 1. Blood lipid profile

Blood lipid profile of the normal weight and obese/overweight children in comparison with the reference values are given in Table 4.62.

The various blood lipid parameters studied, included serum cholesterol, serum triglyceride, HDL cholesterol and LDL cholesterol. The serum cholesterol level for normal weight boys and girls were found to be within the desirable level suggested by Hickman *et al*., (2002), whereas a borderline risk was observed among obese/overweight boys and girls. In the case of HDL cholesterol both normal as well as obese/overweight boys and girls were at borderline risk. LDL cholesterol known as bad cholesterol showed a substantial increase with BMI status. Obese/ overweight boys and girls reported in borderline risk in this respect. The normal weight children found to be in a safe position as their LDL levels were within the desirable range of <130 mg/dl. Similar results showing increase in LDL cholesterol values among obese and non obese children has been reported in the studies among children by Chu *et al*., (1998). Garce’s *et al*., (2005) in their survey showed that for obese children of 6 to 8 years of age there was no significant association between obesity and low-density lipoprotein cholesterol. In the same study it is reported that the incidence of elevated serum triglycerides was found to be more among obese vs. non-obese children.

Table 4. 62. Blood lipid profile of normal weight and obese/overweight children

Variables	Reference values (mg/dl)			Boys		Girls	
	Desirable	Border line risk	High risk	Normal weight children (mg/dl)	Obese/ overweight children (mg/dl)	Normal weight children (mg/dl)	Obese/ overweight children (mg/dl)
Serum Cholesterol	<200	200 to 240	>250	176.4±11.72	225.5±13.44	165.2±6.98	221.4±12.99
Serum Triglyceride	<150	150 to 500	>500	112.6±11.35	145.3±24.00	99.0± 2.65	127.4±5.32
HDL Cholesterol	>50	50 to 35	<35	38.4±5.94	47.8± 2.12	43.2±2.168	46.61±1.14
LDL Cholesterol	<130	130-160	>160	115.4±5.18	142.8±13.44	103.4±5.03	149.4±11.39

Ref: Hickman *et al*. (2002)

The most prominent features of the present study were a substantial increase in all the lipid components (Serum cholesterol, serum triglyceride, HDL and LDL) with increase in BMI of both boys and girls. The reduction in HDL cholesterol and elevated levels of LDL and serum cholesterol among the school going population, irrespective of gender are matter of great concern with public health importance. Sinha *et al*., (2002) and Freedman *et al*., (2001) also reported that childhood obesity seems to lead to the appearance of a number of cardiovascular risk factors, such as altered lipid levels and impaired glucose tolerance which could contribute to atheroma plaque development and lead to the development of coronary heart disease in adult life.

4. 5. 2. Blood haemoglobin content and Blood pressure levels of the sample

Haemoglobin content and Blood pressure of obese/overweight and normal children is given in Table 4.63.

Table 4. 63. Distribution of sample based on blood haemoglobin status

Classification	Haemoglobin (mg/dl)	Boys		Girls	
		Normal weight children (mg/dl)	Overweight/ Obese children (mg/dl)	Normal weight children (mg/dl)	Overweight/ Obese children (mg/dl)
Normal	>11	11.98±0.396	12.32±0.364	-	11.4±0.418
Mild Anaemia	9.5-11	-	-	10.2±0.812	-
ModerateAnaemia	8-9.5	-	-	-	-
Severe Anaemia	<8	-	-	-	-

Ref : WHO (1987)

It was seen from the table that except girls of normal weight category, the rest of the school going children studied had normal blood haemoglobin level (>11 mg/dl). Girls with normal weight found to suffer from mild anaemia with a haemoglobin level of 10.2 ± 0.812.

Table 4. 64. depicts the blood pressure of normal weight and overweight /obese children. Blood pressure in general tended to increase with BMI status. Irrespective of gender, systolic and diastolic pressures of the sample were on the higher side than the corresponding values observed among the normal weight children. Further BP of above normal was noticed mostly in the case of diastolic pressure. Overweight and obese boys and girls in the age group of 7 to 9 years and also 10 to 12 year old boys reported having a diastolic pressure above the normal values. Sinaiko *et al*., (2001) and Young-Hyman *et al*., (2001) also reported that obese children are more prone to dyslipidemia, or hypertension. It has been observed that boys of 10 to 12 year age group are more susceptible to hypertension involving both systolic as well as diastolic pressure.

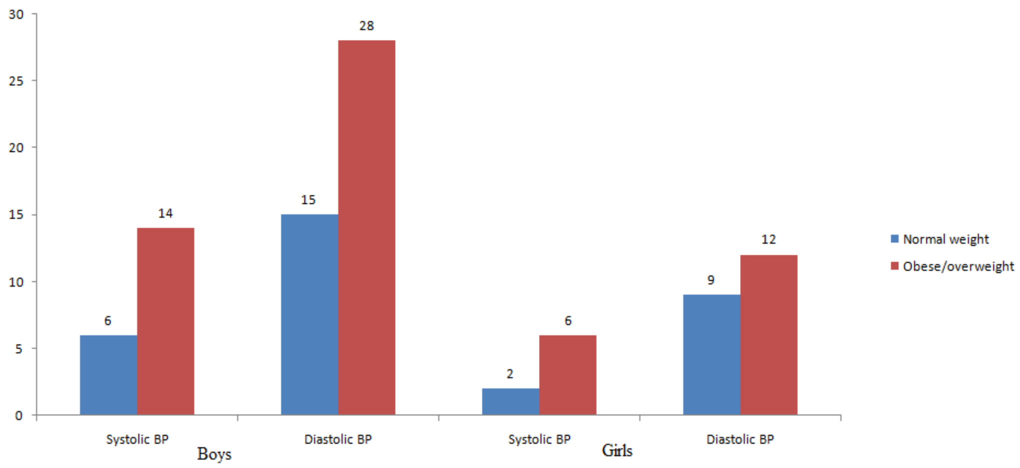

Figure 4. 24. Percentages prevalence of hypertension among the sample

Table 4. 64. Blood pressure of normal weight and overweight /obese children

Variables	Reference values (mg/dl)		Boys		Girls	
			Normal weight children (mg/dl)	Overweight / Obese children (mg/dl)	Normal weight children (mg/dl)	Overweight / Obese children (mg/dl)
Systolic BP (mmHg)	7-9 years	122	110.8 ± 4.21	116.7±5.77	112.0 ± 4.47	115.6 ± 3.58
	10-12 years	124	112.4 ± 8.88	125 ± 4.24	113.4 ± 5.03	118.26 ± 4.32
Diastolic BP (mmHg)	7-9 years	78	75.7 ± 5.33	78.9 ± 4.56	74.6 ± 3.89	79 ± 5.67
	10-12 years	80	76.4 ± 5.9	85.5 ± 6.36	76.6 ± 4.34	78 ± 4.47

Ref: National High Blood Pressure Education Programme Working Group on High Blood Pressure in Children and Adolescents, (2004)

Figure 4. 24. indicates the prevalence of hypertension among normal weight and overweight/obese boys and girls. It was observed that percentage of children having both systolic and diastolic hypertension found to be increased with BMI status. The gender influence in hypertension was also very obvious, with male population more affected than female children. Also in both the genders diastolic hypertension was more common than the systolic hypertension. 28 per cent of overweight/obese boys and 12 per cent of overweight/obese girls had diastolic hypertension followed by 15 per cent of normal weight boys and 9 per cent of normal weight girls. The prevalence of hypertension among children as reported by Raj *et al*., (2007) was 10.10 per cent in normal weight, 17.34 per cent in over weight and 18.32 per cent in obese groups. The prevalence of systolic hypertension in normal weight, overweight and obese groups was reported as 5.38 per cent, 12.31 per cent and 14.66 per cent respectively and diastolic hypertension as 6.45 per cent, 8.86 per cent and 8.9 per cent in the three.

The National High Blood Pressure Education Programme Working Group on High Blood Pressure in Children and Adolescents (2004) reported that children with BP levels ≥120 mm Hg systolic and /or 80 mm Hg diastolic is considered as pre hypertensive. The prevalence of systolic/diastolic pre hypertension was also studied accordingly. The results are presented in Figure 4. 25.

The pre-hypertensive status of the sample showed that boys were more prone to diastolic and systolic pre-hypertension than girls. Also diastolic prehypertension took the head over systolic pre-hypertension in both boys and girls. Raj *et al*., (2007) reported the prevalence of systolic hypertension among children in Kerala as 11.62 per cent, 16.21 per cent and 23.40 per cent respectively among normal weight, overweight and obese children. The prevalence of diastolic pre-hypertension in normal weight, overweight and obese groups was 16.46 per cent, 22.37 per cent and 26.24 per cent respectively.

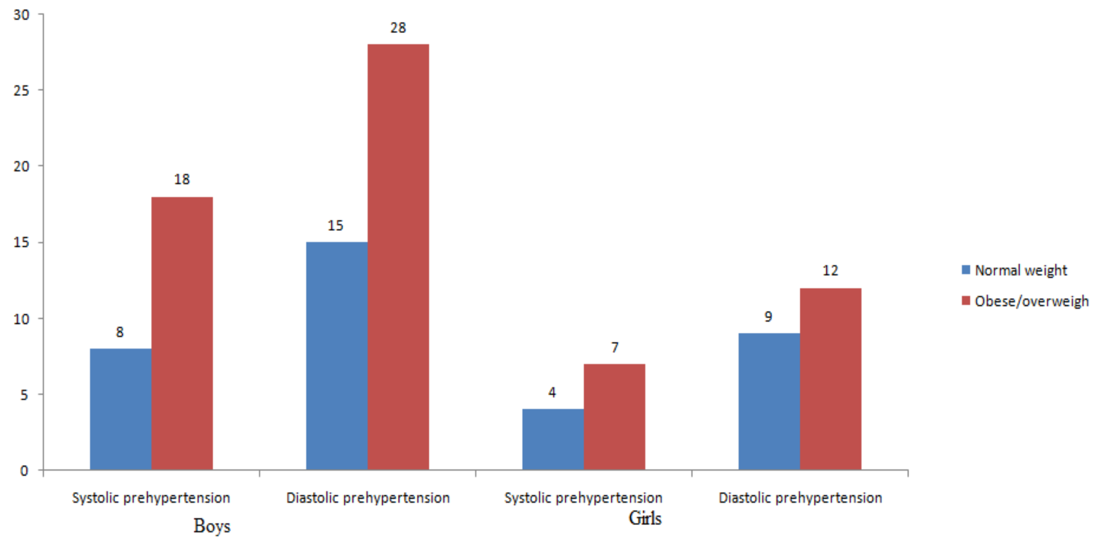

Figure 4. 25. Percentage prevalence of pre-hypertension among the sample

Boys tend to be pre-hypertensive than girls. This is similar to the results reported by Srinivasan *et al*., (1996) and Field *et al*., (2005) who found that male subjects were more likely than female subjects to develop elevated systolic blood pressure. Moreover; diastolic blood pressure in children is subjected to person variability than systolic blood pressure (Gillman and Cook, 1995).

4. 5. 3. Bivariate correlation between biochemical parameters and obesity

From the Table 4. 65, it was obtained that obesity had a highly significant positive correlation (at 1% level) with the entire lipid parameters studied and also with blood haemoglobin and blood pressure (systolic and diastolic). Similarly a positive correlation at a highly significant level (P<0.01) was noted with each and every individual parameter studied under lipid profile and also between blood lipid parameters and BP levels. Whereas no such significant correlation found to exist between blood haemoglobin and blood pressure (systolic and diastolic).

Table 4. 65. Pearson's bivariate correlation between biochemical parameters and obesity

	Obesity	Serum cholesterol	Serum triglyceride	HDL	LDL	VLDL	Haemoglobin	Systolic BP	Diastolic BP
Obesity	1								
Serum cholesterol	0.949**	1							
Serum triglyceride	0.967**	0.984**	1						
HDL	0.739**	0.817**	0.829**	1					
LDL	0.946**	0.994**	0.973**	0.768**	1				
VLDL	0.845**	0.887**	0.881**	0.799**	0.835**	1			
Hb	0.720**	0.625**	0.677**	0.397**	0.646**	0.471**	1		
Systolic BP	0.542**	0.523**	0.446**	0.469**	0.517**	0.454**	0.010	1	
Diastolic BP	0.547**	0.658**	0.645**	0.591**	0.608**	0.832**	0.097	0.340	1

** Significant at 1 per cent level

Obesity having a highly significant positive correlation with serum cholesterol as observed in the present study, has been reported by Wang and Lobstein, (2006) and Ming *et al*., (2009).

Similarly, serum triglycerides showing a strong positive correlation, significant at one per cent level with obesity and serum cholesterol has also been described in studies conducted both in adults and children (Berns *et al*., 1989). The study also showed a positive correlation with HDL cholesterol and increased weight, serum cholesterol, serum triglycerides. The results seem to be contradictory to findings of Daniels *et al*., (1999); Haarbo *et al*., (1990) and Haarbo *et al*., (1989) who have reported a negative correlation of HDL cholesterol with serum cholesterol, serum triglyceride and LDL cholesterol. Low density cholesterol in this study was found to have a strong positive association with obesity/overweight, serum cholesterol, serum triglyceride and HDL cholesterol. The same type of positive correlation was observed with VLDL also.

All the serum lipid components and haemoglobin was found to be positively correlated at a significant level ($p<0.01$). Systolic and diastolic blood pressure had correlation with lipid profile and not with haemoglobin. Several studies have reported strong positive correlation with blood pressure and BMI. Lauer and Clarke (1989) observed that both BMI in childhood and change in BMI were correlated with blood pressure and BMI in adulthood. Similarly, Srinivasan *et al*., (1996) observed that in a biracial sample of 783 people, initially 13 to 17 years old and then followed up when they were 27 to 31 years old. It was seen that those who had been overweight as adolescents were significantly more likely to report hypertension and high cholesterol as young adults.

4. 5. 4. Correlation between blood lipid profile and BMI of the sample

The correlation is illustrated in the Figures 4. 26. to 4. 30. and the relations derived through regression analysis are given in Table 4.66.

Boys **Girls**

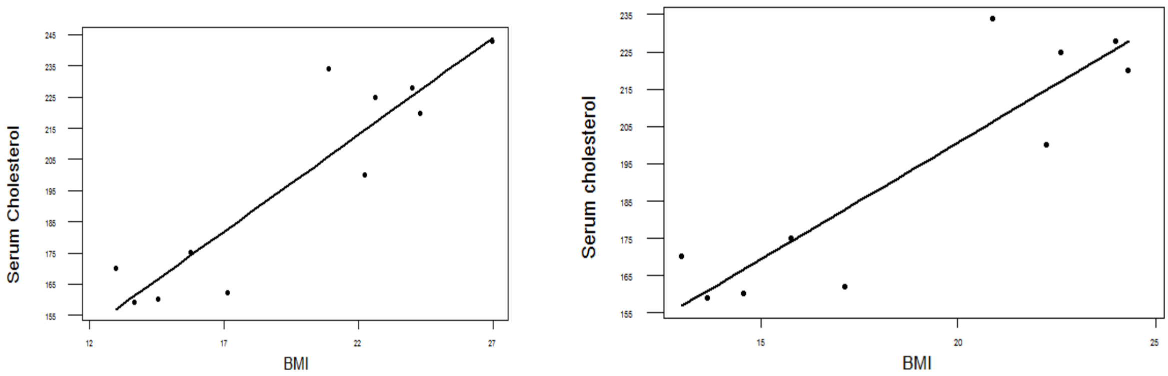

Figure 4. 26. Changes in the serum cholesterol status with BMI

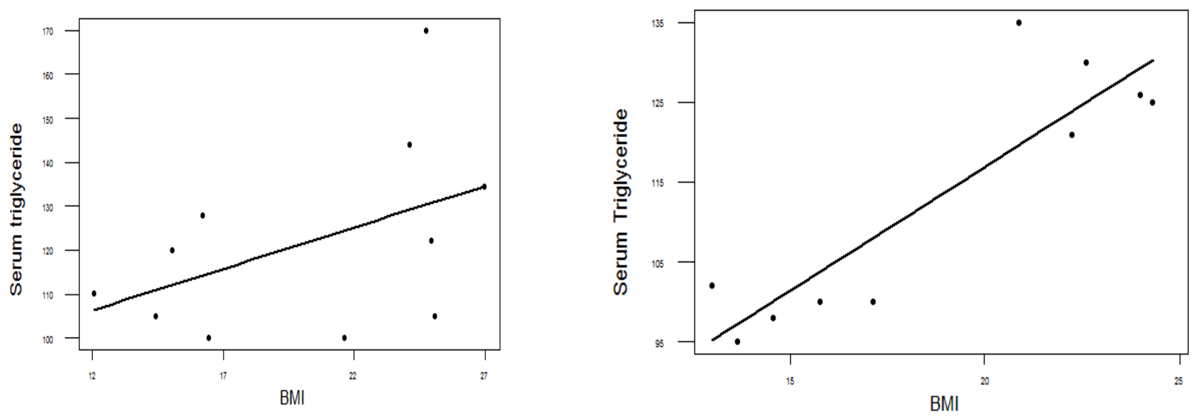

Figure 4. 27. Changes in the serum triglycerides status with BMI

Boys **Girls**

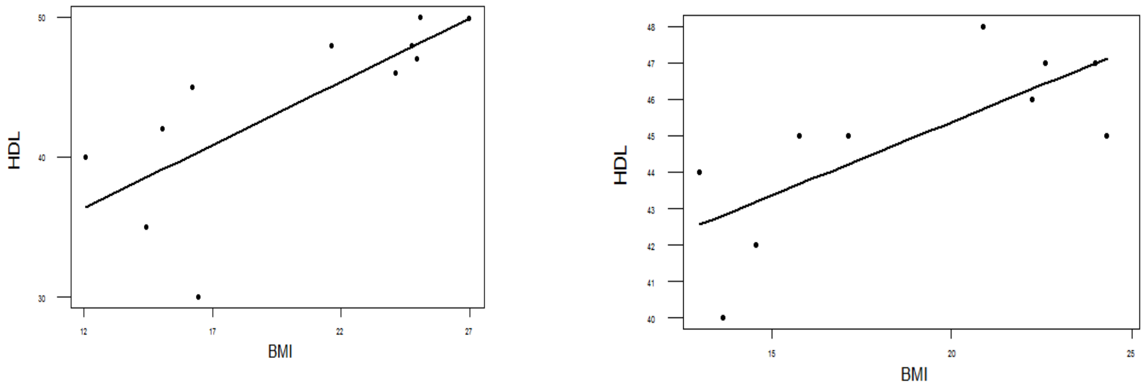

Figure 4. 28. Changes in the HDL levels with BMI

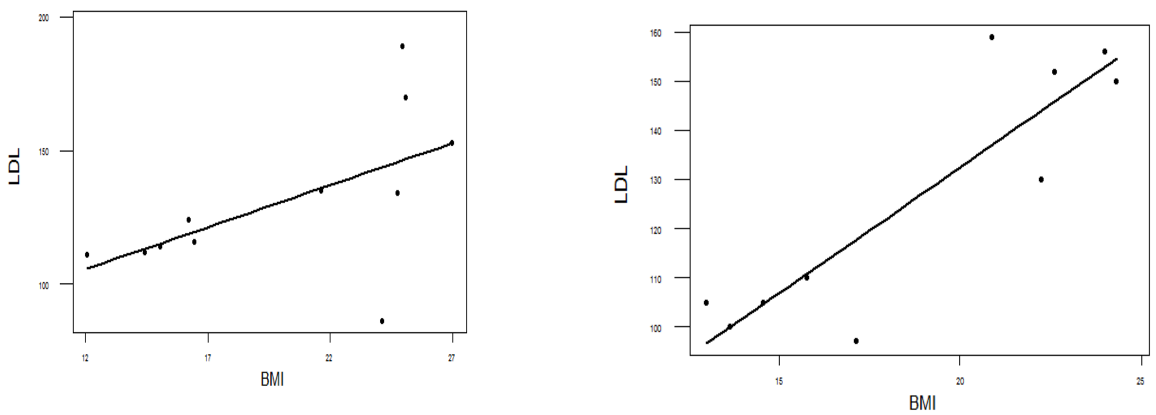

Figure 4. 29. Changes in the LDL levels with BMI

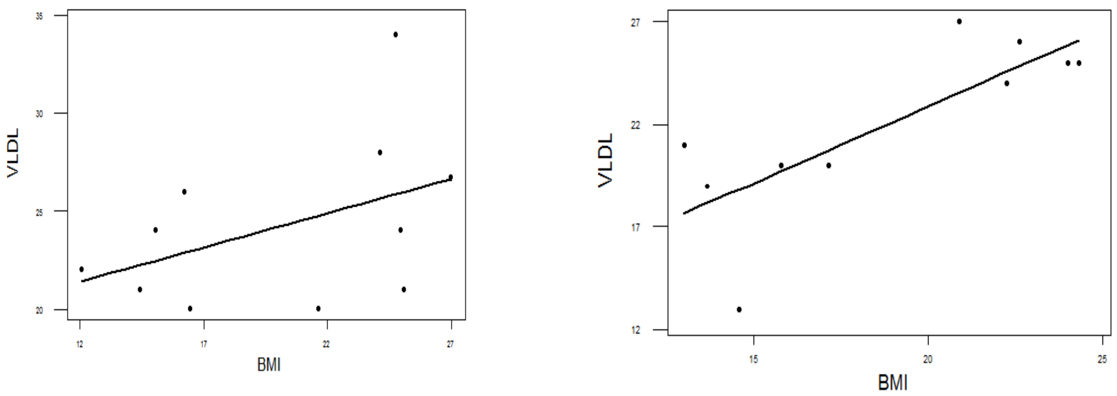

Figure 4. 30. Changes in the VLDL levels with BMI

Table 4. 66. Regression relation derived from correlation of BMI and Blood lipid profile

Lipid profile	Boys	Girls
Serum cholesterol	y = 76.39+6.21x	y = 75.61+6.26x
Serum triglycerides	y = 83.77+1.88x	y = 54.92+3.10x
HDL cholesterol	y = 25.6+0.90x	y = 37.32+0.40x
LDL cholesterol	y = 67.9+3.14x	y = 30.36+5.11x
VLDL cholesterol	y = 17.26+0.35x	y = 7.94 +0.75x

x represents BMI

A smooth and direct rise of serum cholesterol with BMI was observed in boys and girls which indicated that serum cholesterol is directly related to BMI. Similar results have been reported by Higgins *et al*., (2001) who found an increase in serum cholesterol with obesity. However in a study conducted among 6 to 8 year old children in Spain, serum cholesterol was found to behave differently with no rise with increasing BMI (Garce’s *et al*., 2005).

A steady progressive increase was also reported in serum triglycerides , with the advancement of BMI. Chu *et al*. (1998), Wattigney *et al*. (1991) and Ronnemaa *et a*l., (1991) found the similar trend of rise in serum triglyceride with adiposity among children.

The regression relation between BMI and HDL was y = 25.6+0.90x for boys and y = 37.32+0.40x for girls where, y is HDL and x is BMI, resulting in increase of HDL levels with BMI. However this is not in line with the findings of Garce’s *et al*., (2005) who have reported a lower HDL cholesterol levels for obese children when compared to non-obese children. The present observation although not in line with other studies, is a positive sign, need to be investigated further. LDL cholesterol increased with overweight and obesity. Garce's, (2002) and Matthews *et al*. (1985) also reported a positive association of low density lipoprotein with adiposity. LDL is the main carrier of cholesterol and is called 'bad cholesterol' because it causes atherosclerosis. The increase in LDL cholesterol levels of girls with BMI, was more obvious and steep than boys.

The empty VLDL becomes LDL. It is less harmful than LDL but still can damage the arterial lining. The VLDL of the sample showed a gradual increase with BMI. The VLDL travels through the blood vessels to unload fat throughout the body. The increase in VLDL levels with BMI, among girls, was steady and steeper than boys. The regression relation between BMI and VLDL was $y = 7.94+0.76x$ where, y is VLDL and x is BMI.

4.5. 5. Correlation between blood pressure and BMI

The correlation between blood pressure and BMI is illustrated in Figures 4. 31. and 4. 32.

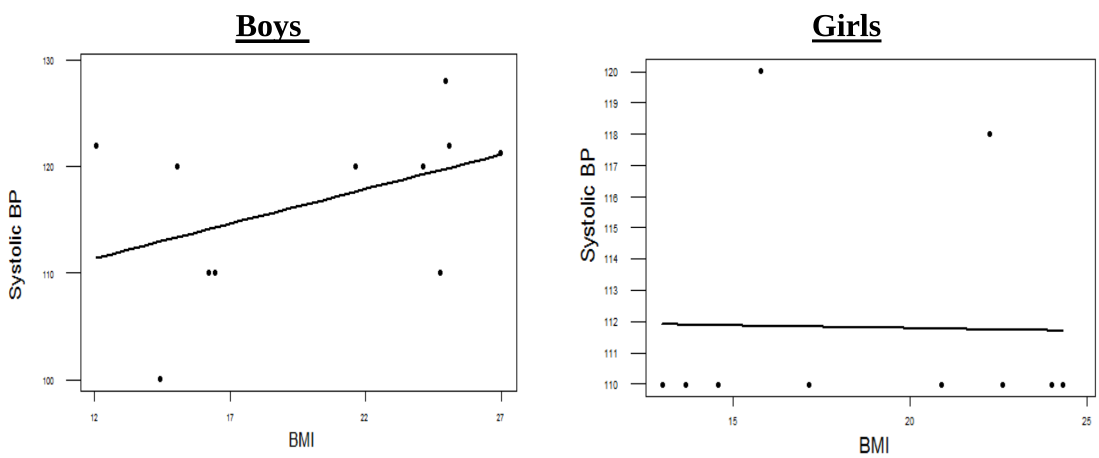

Figure 4. 31. Changes in Systolic BP with BMI

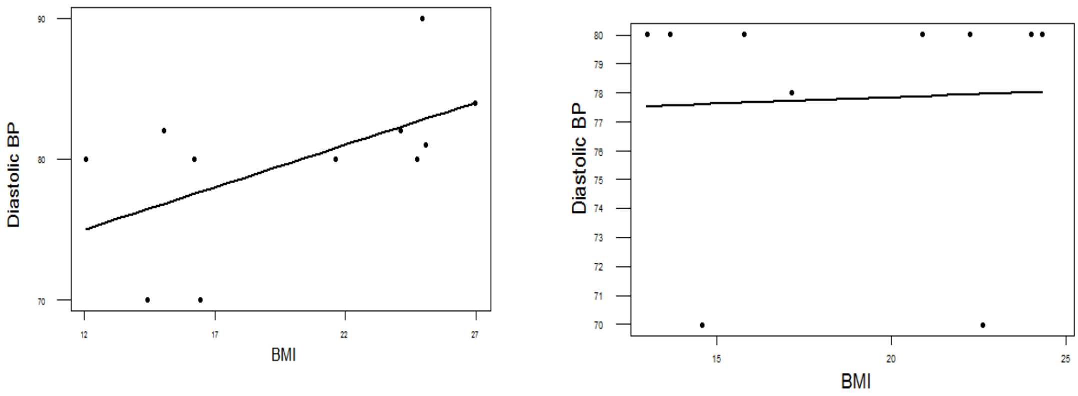

Figure 4. 32. Changes in the Diastolic BP with BMI

The regression equations derived from the correlation of BMI and blood pressure is given in Table 4.67. These equations enable to determine the blood pressure of school children (7 – 12 years) from their BMI values.

Table 4. 67. Regression relation derived from correlation of BMI and Blood pressure

Boys		**Girls**	
Systolic BP	**Diastolic BP**	**Systolic BP**	**Diastolic BP**
y = 104+0.64x	y = 67.6+0.61x	y = 112-0.02x	y = 77.0+0.04x

x represents BMI

The change in systolic blood pressure among boys and girls with their BMI is presented in Figure 4.31. The systolic blood pressure of the sample (boys) was correlated with their BMI and the regression relation between BMI and Systolic BP was y = 104+0.64x where, y is Systolic BP and x is BMI. The systolic blood pressure reported a slow but steady increase with BMI in the case of boys. Similar results have been reported by Raj *et al*., (2007); Field *et al*., (2005) and Srinivasan *et al*., (1996).

Although there observed slight changes in the mean values of BP with BMI, the difference was not as obvious as that of boys. This is similar to the results reported by Srinivasan *et al*., (1996) and Field *et al*., (2005) who found that male subjects were more likely than female subjects to develop elevated systolic blood pressure with BMI. The regression relation between BMI and Systolic BP for girls was $y = 112 - 0.02x$ where, y is Systolic BP and x is BMI.

The Diastolic BP (normal and overweight/ obese) with increase in BMI is presented in Figure 4.25. The regression relation between BMI and Diastolic BP was $y = 67.6 + 0.61x$ where, y is Diastolic BP and x is BMI. The trend in this increase of diastolic blood pressure with BMI among boys was almost similar to that of their systolic blood pressure. A gradual and steady rise in diastolic BP with increase in BMI was noticed among boys.

In the case of girls, as figure 4.32 illustrates, the diastolic blood pressure did not show much change with increase in BMI. Here also the trend was similar to that of their systolic pressure (not much change with BMI). The regression relation between BMI and Diastolic BP was $y = 77.0 + 0.04x$ where, y is Diastolic BP and x is BMI.

4.5.6. Formulation of a predictive index for overweight/obesity based on the biochemical parameters

Boys

The predictive index for childhood obesity for boys is $y = 20.4 + 0.169x_1 + 0.90x_2 + 0.278x_3 - 0.015x_4 + 0.2x_5 - 0.831x_6 - 4.18x_7$

Where, x_1 – Serum cholesterol, x_2 – Serum TG, x_3 – HDL, x_4 – LDL, x_5 – Systolic BP, x_6 – Diastolic BP and x_7 – VLDL.

Girls

The predictive index for childhood obesity for girls is y=-65.0+0.006x_1+0.149x_2-0.06x_3+0.067x_4+0.133x_5-0.001x_6

VLDL is highly correlated with other variables and hence been removed from the equation.

4. 6. Multiple correlates of obesity among school children

4. 6. 1. Correlation of BMI with *Physical body parameters*

4. 6. 2. Correlation of BMI with *Body compositional parameters*

4. 6. 3. Correlation of BMI with *Birth and Family Related parameters*

4. 6. 4. Correlation of BMI with *Food habits and life style related parameters*

4. 6. 1. Correlation of BMI with *Physical body parameters*

Pearson's product moment correlation coefficients measure the degree and direction of a linear relationship between two variables. The correlation coefficients between BMI and physical body parameters such as height, weight, MUAC, waist circumference, hip circumference and waist-to-height ratio were worked out and the results are presented in Table 4. 68.

The negative correlation between BMI and height, as the definition of BMI suggests, was proved in this study also. The coefficient (-0.562) was significant at 1 per cent level. Similarly, BMI was strongly and positively correlated (0.848) with the body weight at 1 per cent level.

The association between MUAC and BMI was significant at 1 per cent level (0.848). The finding is in line with the previous observations by Garcia *et al.,* (2005). The association of waist circumference with BMI was also highly significant (0.795) at 1 per cent level. This is in line with the numerous previous reports (Yan *et al*., 2007; Ashwell and Hsieh, 2005; Zhu *et al*., 2004; Ardern *et al*., 2003; Frontini *et al*., 2001; Higgins *et al*., 2001; Wei *et al.*, 1997 and Pouliot *et al*., 1994). The hip circumference was also positively correlated with BMI ($p<0.01$). The hip circumference is a measure on the accumulation of body fat and the efficiency of this factor as a predictor of obesity and related health risks was previously reported by Merchant *et al*., (2007); Yannakoulia *et al*., (2006); Malecka-Tendera *et al*., (2005); Spencer *et al*., (2004); Onat, (1999) and Han *et al*., (1998).

From this study, it is clear that with increase in BMI, there will be corresponding increase in the circumferences of both waist and hip. But the extent of increase in the the waist circumference increase will be faster than that of hip. This makes the ratio of these factors, waist-to-hip ratio, a reliable predictor of obesity (Chen *et al*., 2001; Ashwell, 1997; Bjorntorp, 1988 and Onat, 1999).

Waist to height ratio ($p<0.01$) was also increased with the body fat. The strong association between the waist to height ratio and the body fat is an indicator that waist to height ratio could be used for predicting the obesity (Janssen *et al*., 2004). The body height and weight were positively associated and this observation is due to physical growth and development of children. The hip circumference has registered a significant positive correlation with waist circumference ($p<0.01$). This is a well studied relation (Goran, 1998; Garcia *et al*., 2005; Pratanaphon *et al*., 2007; Daniels *et al*., 2000; Cachera *et al*., 1984; Pecoraro *et al*., 2003). All the parameters studied found to have a highly significant ($p<0.01$) positive correlation except BMI vs height, height vs waist to height ratio, where the correlation was found to be negative ($p<0.01$).

Table 4. 68. Correlation matrix on BMI and *physical body parameters*

	BMI	Height	Weight	MUAC	WC	HC	Waist-to-height ratio
BMI	1	-0.562**	0.848**	0.848**	0.795**	0.815**	0.617**
Height		1	0.772**	0.484**	0.389**	0.636**	-0.240**
Weight			1	0.836**	0.747**	0.894**	0.281**
MUAC				1	0.834**	0.878**	0.560**
WC					1	0.818**	0.798**
HC						1	0.447**
Waist-to-height ratio							1

** Significant at 1% level

4.6.2. Correlation of BMI with *Body composition*

Correlation of BMI with the components of body composition such as body density, body fat %, lean body mass, biceps, triceps subscapular and abdominal fat was calculated and the results are given in Table 4. 69. It was observed that the components of body composition studied were positively correlated (significant at 1% level) with the BMI and hence with the overweight and obesity.

The highly significant ($p<0.01$) positive relation between body density and BMI as indicated by higher skin fold thickness was previously reported by Sweeting (2007), Janssen *et al*., (2004) and Lohman (1981). The body fat percentage also had a positive correlation with the BMI, which was significant at 1 per cent level. This finding is in line with the previous findings of Reilly *et al*., (2006), Janssen *et al*., (2004), Field *et al*., (2003), Mei *et al*. (2002) and Deurenberg *et al*., (1990).

In this study, lean body mass showed a strong and positive correlation with the BMI. Mykkanen *et al*. (1992) also noted that BMIs is positively correlated with lean body mass.

The triceps measurement was also directly and positively correlated with the BMI, which was also documented in previous studies by Michielutte *et al*., (1984), Must *et al*., (1991), Chinn and Rona (1994), Ong *et al*., (2000), Mei *et al*., (2002), Wang *et al*., (2003), Elberg *et al*., (2004), Chhatwal *et al*., (2004), Stevens *et al*., (2004), Garcia *et al*., (2005), Stettler *et al*., (2007) and Garcia-Marcos *et al*., (2008).

Similarly, significant correlation of subscapular skin thickness with the BMI ($p<0.01$) was in line with the findings by Cachera *et al*., (1984), Slaughter *et al*., (1988), Reilly *et al*., (1995), Daniels *et al*., (1999), Frontini *et al*., (2001), Stevens *et al*., (2004) and Garcia *et al*., (2005).

Table 4. 69. Correlation matrix on BMI and *Body composition*

	BMI	Body density	Body fat (%)	Lean body mass	Biceps	Triceps	Subscapular	Abdominal fat
BMI	1	0.878**	0.798**	0.829**	0.558**	0.801**	0.796**	0.777**
Body density		1	0.953**	0.694**	0.630**	0.946**	0.944**	0.944**
Body fat (%)			1	0.639**	0.643**	0.914**	0.897**	0.887**
Lean body mass				1	0.426**	0.641**	0.663**	0.667**
Biceps					1	0.627**	0.557**	0.591**
Triceps						1	0.824**	0.822**
Subscapular							1	0.878**
Abdominal fat								1

** Significant at 1% level

The abdominal fat thickness in the present study, showing a highly significant ($p<0.01$) positive correlation with BMI was supported by the observations of many researchers such as Daniels *et al*., (1999), Janssen *et al*., (2004) and Merchant *et al*., (2007). Although it has been hypothesized that the health risk associated with obesity is determined primarily by the amount of visceral fat (Despre's *et al*., 1990; Brochu *et al*., 2000; Ross *et al*., 2002), this is an ongoing topic of debate (Frayne, 2000; Seidell and Bouchard, 1997), and many studies have demonstrated that total fat mass (Goodpaster *et al*., 1997; Toth *et al*., 2001) and abdominal subcutaneous fat (Goodpaster *et al*., 1997; Misra *et al*., 1997; Toth *et al*., 2001; Kelley *et al*., 2000) are also independent predictors of insulin resistance.

Abdominal fat deposition was also proved to be positively correlated with BMI, triceps and sub scapular fat accumulation. Such a positive relation between abdominal adiposity and BMI has been reported previously by Valdez *et al*., (1993).

Thus the study could brought out a highly significant ($p<0.01$) positive correlation between BMI and all the parameters considered under body composition.

4. 6. 3. Correlation of BMI with *Birth and Family Related parameters*

Correlation of BMI with *Birth and* Family Related parameters such as birth weight, birth order, type of family, educational level of father, educational level of mother, monthly income, number of adults in the family and number of children in the family were interpreted statistically and is discussed in Table 4.70. The Pearson's bivariate correlation analysis on the school children had shown that BMI is significantly and positively correlated with the birth weight of the child (0.576) *ie* if the birth weight is more there are more chances of becoming obese. The childhood as well as adolescent obesity risk was well correlated with the birth weight in many of the previous studies (Wolff, 1955; Salbe *et al*., 2002; Curhan *et al*., 1996;

Table 4.70. Correlation between BMI and *Birth/ family related parameters*

	BMI	Birth weight	Birth order	Breast feeding	Type of family	Educational level of father	Educational level of mother	Monthly income	Number of adults in the family	Number of children in the family
BMI	1	0.576**	- 0.422**	-0.386**	- 0.314**	0.342**	0.302**	0.501**	-0.075	- 0.104*
Birth weight		1	-0.565**	0.087	-0.163**	0.272**	0.200**	0.356**	0.123**	-0.183**
Birth order			1	0.216**	0.180**	-0.119**	-0.065	-0.262**	-0.126**	0.383**
Breast feeding				1	0.017	0.456**	0.365**	0.007	0.104*	0.315**
Type of family					1	-0.472**	-0.274**	-0.179**	-0.889**	-0.289**
Educational level of father						1	0.815**	0.564**	0.431**	0.171**
Educational level of mother							1	0.561**	0.262**	0.098*
Monthly income								1	0.169**	-0.075
Number of adults in the family									1	0.498**
Number of children in the family										1

** Significant at 1% level, *Significant at 5%level

Danielzik *et al*., 2004; Gillman *et al*., 2003; Kuh *et al*., 2002; Monteiro *et al*., 2003; Parsons *et al*., 1999; Phillips and Young, 2000; Singhal *et al.*, 2003; Sørensen *et al*., 1997).

Apart from this, the birth order was negatively and significantly correlated with the BMI (-0.422). Previous studies by Ravelli and Belmont, (1979) had clearly shown that with the increase in the birth order, the chance of child becoming overweight will be lesser. The first child being a new change and experience of the family, he will be the centre of attraction and when the number of children in the family increase, the care received by individual child comes down and this is the reason for the observed negative correlation (Stettler *et al*., 2003). These results are further supported with the significant and negative correlation observed between number of children in the family and BMI (-0.104).

Other worth mentioning relation was the significant (at 1% level) negative correlation between birth weight and birth order (-0.565). The first child in the family registered good birth weight and birth weight was positively related with the higher risk of obesity.

Breast feeding was found to be negatively correlated with the BMI (-0.386). to a highly significant level (1% level). This is a well established fact by a number of studies. Successful breast feeding reduces the risk of obesity in children (Neutzling *et al*., 2009; Koletzko *et al*., 2009; Procter and Holcomb, 2008; August *et al*., 2008; David *et al*., 2007; Gunderson, 2007; Toschke *et al*., 2007,2003; Schaefer-Graf *et al*., 2006; Davis *et al*., 2006; Taveras *et al*., 2006; Owen *et al*., 2005a, 2005b; Harder *et al*., 2005; Arenz *et al.*, 2004; Bogen *et al*., 2004; Grummer-Strawn and Mei, 2004; Parsons *et al*., 2003; Clifford, 2003; Bergmann *et al.*, 2003; Dewey, 2003; Armstrong and Reilly, 2002; Butte, 2001; Gillman *et al*., 2001; Butte *et al*., 2000;

Dietz, 2001b; Hediger *et al*., 2001; Poothullil *et al*., 2001; von Kries *et al*., 1999a, 2000; Wadsworth *et al*., 1999). Lucas *et al*., (1980 and 1981) found significantly higher plasma concentration of insulin in infants, who had been bottle fed than in infants who had been breast fed; these higher concentrations would be expected to stimulate fat deposition and the early development of adipocytes. Breast milk also contains bioactive factors which may modulate epidermal growth factor and tumour necrosis factor both of which are known to inhibit adipocyte differentiation *in vitro* (Hauner *et al*., 1995; Petruschke *et al*., 1994). The amount of energy metabolised and the protein intake of breastfed children is considerably lower than the intake of infants who are fed on formulas (Whitehead, 1995; Heinig *et al*., 1993).

The type of family had a significant negative correlation with obesity (-0.314). Families were classified into nuclear and joint families.Joint families were given the rating of 2 and nuclear families 1. These ratings were used in correlation analysis against BMI and other birth/ family factors. From the negative and significant correlation, it was clear that children in the nuclear families were at a higher risk of being obese. Similarly, number of adults in the family and BMI had a negative correlation, though not significant statistically (-0.075). These findings are in line with the previous findings by Ravelli and Belmont, (1979).

The educational level of father and mother were positively and significantly correlated with the BMI (0.342 and 0.302 respectively). But in Germany, children of parents with low education had more than three fold risk to be obese than children of parents with high education (Lamerz *et al*., 2005). The educational level of parents was also positively correlated with the birth weight of the child (0.272 and 0.200 respectively for father and mother) at a highly significant level. This is in line with the previous discussion on the positive association between BMI and educational status of parents, clarifying the path through which the educational status BMI gets associated. It may also be noted that educational level of parents is negatively correlated with the birth order (-0.119 and -0.0.065) ie., well educated parents prefer to have lesser number of children, again contributing for a higher BMI since the number of children in the family and BMI are negatively associated.

In Kerala, high educational status is always associated with better employment and hence better family income. In this study also, family income was strongly associated with higher BMI (0.501). This situation is often associated with less energy expenditure, calorie dense foods, lesser involvement in home-level/outdoor physical activities, more involvement with TV and computer games etc.

In Brazilian population, Monteiro *et al*. (1995) have noted that income and BMI are inversely related in 30 per cent of richest people, but in medium high rich population, income and BMI are directly related. They argue that in very rich population, obesity should have been a menace since long and this makes them highly cautious, bringing the prevalence lesser. In a community that is on the way of being rich, people are yet to realize the implications and to seek remedies (Popkin, 1994, 2001). Similar kind of positive association between income and BMI was reported in many studies (Chang and Lauderdale, 2005; Pickett *et al*., 2005; Vandegrift and Yoked, 2004; Monteiro *et al*., 2001; Sichieri *et al.*, 1994).

Breast feeding practice reported to have a very strong and positive relation with the educational status of parents (0.456 and 0.365). Though breastfeeding contributes positively for reduction in BMI, higher income associated with higher education; (0.564 and 0.561 of father and mother respectively) resulting higher energy intake and lesser physical activity increase the risk of obesity for children from these families.

To conclude BMI is significantly and positively correlated to birth weight of the child and educational status of parents. Birth weight of the child is strongly related to educational status of parents and monthly income of the families. Breast feeding is found to be positively correlated to educational status of parents whereas a strong negative correlation was seen between birth order and BMI, birth weight and birth order, breast feeding and BMI, type of family and BMI.

4. 6. 4. Correlation of BMI with *Food habits and life style related parameters*

The influence of various lifestyle factors and food habits of children on the incidence of obesity was studied and is presented in Table 4.71.

Time spent on sports was recorded as the total number hours of involvement in indoor or outdoor games in a week and this was found to be significantly and negatively correlated with the BMI. This shows that involvement in sports reduces the chance of obesity in school children.

This is a well understood relation and these results are well supported by the findings of Reilly *et al*., (2006, 2004), Fisher *et al*., (2005), Stevens *et al*., (2004) Reilly and McDowell, (2003a), Puyau *et al*., (2002) and Williamson, (1994). For all the obesity prevention programmes designed worldwide, sports is the most promising component (Going *et al*., 2003; Story *et al*., 1999; Caballero *et al.*, 1998; Maffeis *et al.*, 1998 and Broussard *et al*., 1995).

Time and mode of travel and involvement in household activities, the direct ways for energy expenditure through enhanced physical activities and higher energy expenditure on travel, was also proved to be efficient to reduce the BMI (-0.172).

Table 4. 71. Correlation of BMI with *Food habits* and *lifestyle related parameters*

	Time spent on sports	**Energy spent on travel**	**Energy spent on household activities**	**Time spent on Television viewing**	**Energy spent on physical training at school**	**Energy spent on Yoga/ exercise at home**	**Food habit**	**Frequency of food outside home**
BMI	-0.343**	-0.172**	0.035	0.341**	-0.180*	-0.085	-0.073	0.528**

**Pearson's bivariate correlation is significant at the 0.01 level (2-tailed), *Significant at the 0.05 level

The energy spent on travel was measured as a product of the distance between the school and the rating of mode of travel. Modes that demand higher energy expenditure such as cycling were given higher rating. Previous findings in this respect by Keith *et al*., (2006), Malina and Katzmarzyk, (2006); Ramachandran, (2004), Wagner *et al*., (2001), Booth *et al*., (1997), Chen and Asami, (1987), also showed that the reduction in the energy spent on travel leads to increased obesity.

Though the household physical activities are proved to be efficient to reduce the chances of obesity (Tremblay and Willms, 2003; Katzmarzyk *et al*., 1998a, 2003; Malina, 2001, Welk *et al*., 2000; Maffeis *et al*., 1998) the present study did not show any significant correlation between these two factors, which is predictive that school going children do not spend much energy in the household activities.

Time spent on television viewing was significantly correlated with the BMI (0.341). The negative impact of television viewing on physical fitness and as a means for overweight/ obesity is well demonstrated (Steffen *et al*., 2009; Poskitt, 2009; Sugarman and Sandman, 2008; Lagiou and Parava, 2008; Wells *et al.*, 2008; Nelson *et al*., 2006; Dennison *et al*., 2006; Blass *et al*., 2006; Reilly *et al*., 2005; Kolagotla and Adams, 2004; Sherwood *et al*., 2004; Vandewater *et al*., 2004; Beech *et al*., 2004; Robinson *et al*., 2003; ; Giammattei, *et al*., 2003, Hu *et al*., 2003; Proctor *et al.*, 2003; Ruangdaraganon *et al.*, 2002; Janz *et al*., 2002; Ford *et al.*, 2002; Robinson, 2001; Crespo *et al*., 2001; Faith *et al.*, 2001; Coon *et al*., 2001; Hernandez *et al*., 1999; Jeffery and French, 1998, Andersen *et al*., 1998; Katzmarzyk *et al*., 1998b; Dietz, 1993; Klesges *et al.*, 1993; Dietz and Gortmaker, 1985; Murray and Kippax, 1977).

School based physical training observed to have a significant role at 5% level in reducing the BMI among school children (-0.180). Studies by Sahota *et al*.

(2001), Reniscow (1993), Parcel *et al*. (1988) and Tones (1996) approve this finding. Yoga/exercise at home is also proved effective for reducing the risk of obesity (Divakar *et al*., 1978). In present study, though yoga/ exercise at home found to reduce the BMI, the correlation coefficient was not statistically significant (-0.085). This may be due to the fact that the fraction of sample that practicing yoga/exercise on regular basis was only meagre and the mean frequency was only 0.79 days in a week. This may be the reason for the failure of establishing a significant correlation between yoga/ home level exercise and BMI in the present study.

As far as the food habits are concerned, the vegetarian or non-vegetarian foods failed to show any significant effect on the BMI status (-0.073). Dwyer *et al.*, (1980) also failed to draw any solid difference among vegetarian and non-vegetarian foods in their capability to enhance BMI. Studies by Brathwaite *et al*., (2003) had shown that only long term practice of vegetarianism could reduce the BMI and this condition may not be applicable to the sample population in the present study. In the light of the findings by Kennedy *et al*. (2001), more than diet composition, energy restriction plays a key role in weight management and it cannot be expected to have a lesser BMI in vegetarians among the Kerala population. Further, lion share of the non-vegetarians in Kerala are fish eaters rather than meat eaters. It is shown that fish eaters will have lower BMI on par with the vegetarian foods (Spencer *et al*., 2003) and this again complements the insignificant correlation of food habit with BMI in this population.

But frequency snacking and fast food intake recorded a very strong and positive correlation (at 1% level) with the BMI (0.528). The association of frequent intake of food from restaurants and fast food intake with higher obesity risks, is well documented (Navarro *et al*., 2004; Mc.Nutt *et al.*, 1997; Sherwood *et al*., 2004;

Sweeting, 2007; Keith *et al*., 2006; Ramachandran, 2004; Troiano *et al*., 2000; Olivares *et al*., 2004; Poskitt, 2009; Sugarman and Sandman, 2008; Bellisle *et al*., 1988; Agras and Mascola, 2005; Drewnowski, 1998, 2007, 2009; Drewnowski *et al*., 2004; Monsivais and Drewnowski, 2007; Darmon *et al*., 2002; Jason *et al*., 2009; Crawford *et al*., 2009; Giammattei *et al*., 2003; Blass *et al*., 2006; Jeffery and French, 1998).

In short sedentary life style and energy conservation with less outdoor and indoor activities coupled with intake of calorie dense foods especially from outside restaurants and fast food centres were the major factors contributing to childhood obesity. Food habits like vegetarianism and non vegetarianism did not show much effect on BMI. At the same time school based physical training found to have a significant role in reducing BMI.

4. 7. Prediction Index for childhood obesity

4. 7. 1. Factor analysis of principal components

4. 7. 2. Prediction Index

4. 7. 1. Factor analysis of principal components

A principal component analysis is concerned with explaining the variance covariance structure of a set of variables through a few linear combinations of these variables. Principal components are linear combinations of original variables and are derived in decreasing order of importance. So in the present study, first two factors in the Factor analysis and the loading plot of the Factor analysis revealed the dynamics of variables under study (Figure 4.33.).

The loading plot revealed that MUAC, WC, biceps, triceps, subscapular fat, abdominal fat, body fat, weight, HC and WHTR had shown a positive loading along with BMI, showing that these are the factors that should be involved in the Prediction Index. It may be noted that all these factors had a positive and highly significant correlation with BMI (MUAC-0.882, WC-0.836, Biceps-0.868, Triceps-0.838, Subscapular-0.837, Abdomen-0.812, Body fat percentage-0.829, Weight-0.862, HC-0.842, WHTR-0.680).

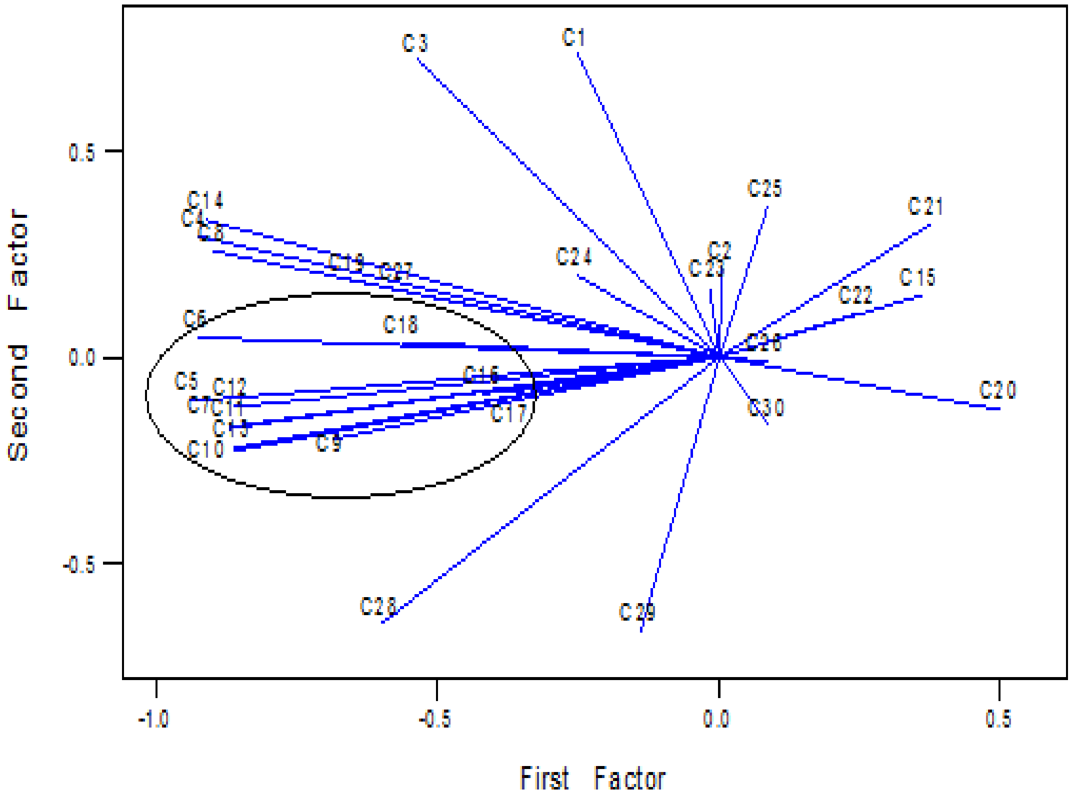

Figure 4. 33. Loading plot for first two factors in factor analysis of principal components derived from the correlation coefficients of 30 obesity related variables (after data transformation to 0-1 scale) in school children (C1-Age, C2-Gender, C3-Height, C4-Education of father, ***C5-BMI***, ***C6-MUAC***, ***C7-WC***, C8-Education of mother, ***C9-Biceps***, ***C10-Triceps***, ***C11-Subscapular***, ***C12-Abdomen***, ***C13-Body Fat***, C14-Lean body mass, C15-Family type, ***C16-Weight***, ***C17-HC***, ***C18-WHTR***, C19-Monthly income, C20-Birth order, C21-Time spent on sports, C22-Energy spent on travel, C23-Energy spent on household activities, C24-Energy spent on physical

training, C25-Energy spent on exercise or yoga, C26-Food habit, C27-Frequency of food outside home, C28-Birth weight, C29-Waist-to-hip ratio, C30-Number of children in the family.)

From the loading plot it was also evident that birth order, time spent on sports, joint family type and energy spent on travel had a negative loading with BMI (Correlation coefficients -0.422, -0.343, -0.314 and -0.172 respectively). Energy spent on exercise or yoga, gender, energy spent on household activities, food habit (vegetarian/Non vegetarian) and number of children in the family had independent loadings with respect to BMI (coefficients -0.085, 0.003, 0.035, -0.073 and -0.104 respectively, all except number of children in the family statistically insignificant even at 0.05 per cent level).

Based on these results derived from the Factor analysis of principal components, variables to be included in Prediction Index formulation were identified and used in multiregression analysis.

4. 7. 2. Prediction Index

For formulation of Prediction Index (PI), obesity was rated with a score of 2, overweight 1 and normality 0.

PI was worked out to be $y = -0.668+5.31C_1+0.008C_2-0.039C_3-0.002C_4+0.0025C_5-0.006C_6+0.0344C_7$ where, C_1-WHTR, C_2-MUAC (cm), C_3-WC (cm), C_4-Subscapular (mm), C_5-Body fat percentage, C_6-HC (cm) and C_7-bodyweight (kg).

Thus if the value of *y* obtained after assigning the values for the independent variables in the linear equation is below 1.0, the sample will be normal, between 1.0 and 1.99 overweight and ≥2.0 obese.

V. SUMMARY AND CONCLUSIONS

The results of the study on "**Multiple correlates of obesity among school children**" are summarized in this chapter. The anthropometric survey for screening obesity among the sample was conducted on a population of 3000 school going children of 7 to 12 years. The socio-economic background, life style of the sample and details regarding the dietary habits were enquired among the parents of all the 3000 samples. The normal, overweight and obese were identified based on CDC percentiles. The dietary recall survey and clinical examination was conducted among the selected subsample of 150 school children with 50 each belonging to normal, overweight and obese category. The biochemical parameters like lipid profile, haemoglobin and blood pressure was done in a sample size of 100 samples with 50 children each belonging to normal and overweight/obese category.

The study was carried out to determine the prevalence of overweight and obesity, to elicit information regarding the socio economic conditions and personal profile, dietary habits of school children, to know the deficiency symptoms and biochemical parameters of normal and overweight/obese children, to know the multiple correlates of obesity and to derive a prediction index for childhood obesity

Anthropometric measurements like weight and height, weight for age classification, height for age classification, BMI, BMI percentiles, MUAC (Mid upper arm circumference), waist circumference, waist circumference percentiles, waist to height ratio, BMI X waist to height ratio percentiles, hip circumference, waist to hip ratio, skinfold thickness, body density, body fat percentage and lean body mass were done using suitable standardized procedures.

Weight and height measurements shows that girls were more malnourished than boys. There is a coexistence of under and over nutrition among school children which demands urgent attention.

There is no widely accepted standard for defining childhood obesity and still is in controversy to have a commonly accepted standard for children. Body mass index of children was compared with standards for adult BMI which is given by James *et al*. (1988) and the modification of the same suitable for adults of Asian population (WHO, 2000). The results were not acceptable since the cut offs available are suitable for adults and hence available percentile values for assessing weight abnormalities in children are used in this study. A comparison of classifying children into different categories depending on their body weight was done using classifications given by International obesity task force (Cole *et al*., 2000), Centre for disease control and prevention (CDC, 2000) and by Indian Academy of paediatrics (Khadilkar, *et al*., 2007). Out of these, children belonging to underweight, normal weight, overweight and obese categories can only be assessed using CDC percentiles, whereas the other two only differentiates the overweight and obese which can be considered as drawback for these classifications. Hence depending on the CDC percentiles an attempt was made to derive the cut-offs suitable for Indian population. On comparing the per cent of children being overweight and obese using these three classifications the prevalence rate was found as 9.84, 9.34 and 6.67 per cent.

A progressive increase in waist circumference with age was reported in the study. Waist circumference was measured to detect the chance of normal and adverse risk factor for cardiovascular diseases in children (Higgins *et al*., 2001). The moderate risk factor for cardiovascular diseases was 13.61 and 16.74 per cent in boys and girls respectively. The chances of severe risk factor for cardiovascular diseases are seen among 8.99 and 5.17 per cent of boys and girls respectively.

Waist circumference centiles (McCarthy *et al*., 2001) using the standard values were compared to detect the overweight and obese. It was observed that overweight were less common among boys than girls. Overweight population among boys was only 1.52 per cent compared to girls (12.49 %) and prevalence of obesity was 19.74 per cent among boys and 18.51 per cent among girls.

Waist to height ratio is more sensitive than BMI as an early warning of health risks. Distribution of school children based on Waist to height ratio (Ashwell and Hsieh, 2005; McCarthy and Ashwell 2003) showed an increased risk for the development of obesity related metabolic syndromes among 9.08 per cent of boys and 8.90 per cent of girls. The use of the cut-off points given by Yan *et al*., (2007) indicated that obesity was high among girls (14.86%) compared to boys (11.26%) whereas overweight was more among boys (11.76%) than girls (6.24%). This prevalence is much higher than those obtained using the other cut off points and further much higher than those reported from other Kerala studies.

BMI percentiles, waist circumference percentiles, and waist to height ratio are the ruling methodologies in establishing the obese and overweight relations in school-going children. Each one suffers from the disadvantage of not considering either one or more of the obesity contributing factors in human growth dynamics, the major being waist circumference and weight. A new methodology for mitigating this defect through considering BMI and waist circumference simultaneously for establishing still efficient percentiles to arrive at obesity and overweight status was tested in this study. Age-wise centiles for obesity and overweight status separately for boys and girls aged 7 to 12 years old were derived. Comparative efficiency of this methodology over BMI had shown that this could mitigate the inability of BMI to consider waist circumference. Also, this had the advantage of considering body weight in obesity analysis, which is the major handicap in waist to height ratio. An analysis using this population has yielded a prevalence of 9.97 which is well within the accepted range for Indian school-going children.

Skinfold thickness of children was measured using Harpenden calipers. Triceps skinfold thickness shows that majority of the boys (89.3 to 97.9%) had more than 15 per cent body fat irrespective of age. Whereas less number of girls (30.5 to 63.4%) compared to boys reported to have a higher (>15%) body fat percentage.

Body density, body fat percentage and lean body mass were also determined using suitable equations. Body density of boys varied between 0.85 to 0.89 and lean body mass from 22.73 to 32.22. Lean body mass tended to increase progressively with age in boys. But this trend was not seen in body density. Girls had more amount of lean body mass than boys till the age of eight and after that boys had more amount lean body mass, with a corresponding increase in body fat percentage among girls up to 11 years. This may be due to reduction in physical activities among girls in pre pubertal period and increase in body fat as a part of pubertal growth.

Socioeconomic background and lifestyle of the sample were collected using a suitable interview schedule. Majority of the families were Hindus followed by Christians and Muslims. Nuclear family system with up to four members in the family that is parents and two children was found in majority of the families. Majority of parents were educated and had satisfactory housing conditions and living facilities.

Majority of fathers were having temporary jobs and 45 per cent of mothers were unemployed. Other details like age of marriage of parents, details regarding breast feeding etc were included in the schedule. Among the selected children majority of them were having normal birth weight and were in the second birth order. Morbidity pattern, physical activity, television/ computer viewing habits, details of travel to school, involvement in household activities of the children were enquired mainly for determining whether the weight abnormalities are correlated to these factors.

Low self esteem, depression, poor academic achievement, stigmatization and discrimination by peers, targets of teasing or bullying, bias and stereotyping by teachers and even some parents, lower body satisfaction were the major psychosocial consequences faced by obese and overweight children.

Dietary practices regarding the food habits and meal pattern of 3000 samples were recorded. Majority of samples were non vegetarians and followed a three major meal pattern. Food expenditure pattern shows that next to cereals (50-60%), the major items for food expenditure was non vegetarian foods like fish (30-40%) and meat (20-30%) and less than 10 per cent expenditure on all the protective foods like pulses, green leafy vegetables and fruits.

Frequency of consumption of foods use of food items by the families revealed that all the families included cereals, fats and oils and sugar and jaggery in their daily diet. Occasional purchase of processed/ ready to eat foods was observed in almost all of the families. The eating habits of children almost resembled the family pattern. In this study it was seen that 76.67 per cent had the habit of eating something while watching television. All children had the habit of taking food from outside, out of which 19.57 preferred to have only vegetarian foods while the remaining 80.43 per cent preferred both vegetarian and non vegetarian foods. A weekly consumption of foods outside home was reported by 84.1 per cent of the families. Monthly frequency was reported by 10.7 per cent and daily consumption was observed among 2.33 per cent of children. Majority (84.8 per cent) were not having a specific time schedule for taking food. It was also reported that due to the busy time schedule majority (74.6) per cent never used to get time to take meals along with family members.

Mean food intake of obese, overweight and normal weight children was found out on a sub sample of 150 children (50 each from the three groups) selected at random. Thus it may be stated that school children of both the age groups (7 to 9 years and 10 to 12 years) exhibited the tendency of consuming more cereals which progressively increased with BMI status. Intake of more than 80 per cent of RDA was observed among obese children with regard to the consumption of energy dense foods such as fats, flesh foods/ eggs and sugar and jaggery in both the age groups (7 to 9 years and 10 to 12 years). These observations clearly predicted the dietary contributions to overweight and obesity among school children. At the same time a progressive reduction of pulses and vegetable consumption with the increase of BMI status and a thoroughly inadequate intake of green leafy vegetables (12 to 36 per cent of RDA) and fruits (38% to 60% of RDA) invariably seen which indicates lack of protein rich and protective foods in the diet of the sample population (7 to 9 year and 10 to12 year old children).

From the recorded food intake, the nutrient intake of children was calculated and compared with RDA given by ICMR, (2009). A significantly higher energy intake and a comparatively higher intake of fat and protein along with a low fibre diet were the root cause of obesity among the age group. Iron deficiency with a significantly lower intake of iron among girls was continued to exist in the 10 to 12 year also. The significant difference in calcium, retinol intake was uniformly seen irrespective of gender. Vitamin C intake was comparatively more among girls than boys. B complex vitamins like thiamine, riboflavin, niacin did not show much difference in their adequacy with gender.

Clinical examination was conducted with the help of a qualified physician. Clinical manifestations of nutritional deficiencies were totally absent among the obese children. Also, comparatively less number of overweight children had any signs of nutritional deficiency. Most of the deficiency signs were observed among the normal weight children. Among the nutritional disorders observed, paleness of eyes due to anaemia was the most prominent one. 24 per cent of normal weight children had this symptom. Protein deficiency in the form of lack of lustre (14%) and thinness and sparseness of hair (12%), diffuse depigmentation (12%) and dyspigmentation (6%) were also observed among normal weight category. The same trend, but to a lesser extent was noticed among the overweight children.

As far as the obese group is concerned, other morbidities like asthma (12%) and tooth decay were more common. The dental carries was also observed in normal weight (10%) as well as overweight children (14%), so also eczema of skin. This skin problem was found to reduce with increase of BMI status. Thyroid enlargement was yet another notable problem among normal weight children (4%).

Biochemical parameters were assessed on a subsample of 100 school children comprising of 50 children of normal weight and 50 from both obese and overweight category. The most prominent features of blood lipid profile were a substantial increase in all the lipid components (Serum cholesterol, serum triglyceride, HDL and LDL) with increase in BMI of both boys and girls.

It was seen that except girls of normal weight category, the rest of the school going children studied had normal blood haemoglobin level (>11 mg/dl). Girls with normal weight found to suffer from mild anaemia with a haemoglobin level of 10.2 ± 0.812.

Blood pressure in general tended to increase with BMI status. Irrespective of gender, systolic and diastolic pressures of the sample were on the higher side than the corresponding values observed among the normal weight children. Further BP of above normal was noticed mostly in the case of diastolic pressure. Overweight and obese boys and girls in the age group of 7 to 9 years and also 10 to 12 year old boys reported having a diastolic pressure above the normal values.

Bivariate correlation between biochemical parameters and obesity revealed a highly significant positive correlation (at 1% level) with all the lipid parameters studied and also with blood haemoglobin and blood pressure (systolic and diastolic). Whereas no such significant correlation found to exist between blood haemoglobin and blood pressure (systolic and diastolic) of the sample.

Correlation between blood lipid profile vs BMI and blood pressure vs BMI of the sample were plotted and regression equations were derived for BMI and blood lipids, BMI and blood pressure.

The predictive index for childhood obesity based on the biochemical parameters for boys is $y = 20.4+0.169x_1+0.90x_2+0.278x_3-0.015x_4+ 0.2x_5- 0.831x_6-4.18x_7$. and for girls it is $y = - 65.0+0.006x_1+0.149x_2-0.06x_3+0.067x_4+0.133x_5-$

$0.001x_6$, where, x_1 – Serum cholesterol, x_2 – Serum TG, x_3 – HDL, x_4 – LDL, x_5 – Systolic BP, x_6 – Diastolic BP and x_7 – VLDL. The mean values of serum cholesterol, serum triglyceride, HDL cholesterol and LDL cholesterol significantly increased with BMI.

Multiple correlates of obesity among school children were assessed using the correlation of BMI with physical body parameters, body compositional parameters, birth and family related parameters and food habits and life style related parameters.

All the physical body parameters studied found to have a highly significant ($p<0.01$) positive correlation with BMI except for BMI vs height, height vs waist to height ratio, where the correlation was found to be negative ($p<0.01$).

Correlation of BMI with the components of body composition such as body density, body fat %, lean body mass, biceps, triceps sub scapular and abdominal fat was calculated. It was observed that the components of body composition studied were positively correlated (significant at 1% level) with the BMI and hence with the overweight and obesity.

The influence of lifestyle factors such as involvement in sports, travel, household activities, television viewing and fitness programmes such as physical training and yoga at school, food habit and frequency of food outside home on obesity was done. Involvement in sports reduces the chance of obesity in school children. Time and mode of travel and involvement in household activities are direct ways for energy expenditure through enhanced physical activities and higher energy expenditure on travel was proved to be efficient to reduce the BMI. . Time spent on television viewing was significantly correlated with the BMI. It was observed that the food habit ie., vegetarian or non-vegetarian has no significant role in increasing the BMI status. Frequency of food outside home and fast food intake had shown a very strong and positive correlation with the BMI.

Loading plot for first two factors in factor analysis of principal components derived from the correlation coefficients was used to decide the variables to be used in a multiregression analysis to formulate a prediction index. PI was worked out to be $y = -0.668+5.31C_1+0.008C_2-0.039C_3-0.002C_4+0.0025C_5-0.006C_6+0.0344C_7$ where, C_1-WHTR, C_2-MUAC (cm), C_3-WC (cm), C_4-Subscapular (mm), C_5-Body fat percentage, C_6-HC (cm) and C_7-bodyweight (kg). When the value of *y* obtained after assigning the values for the independent variables in the linear equation is below 1.0, the sample will be normal, between 1.0 and 1.99 overweight and ≥2.0 obese.

Steps to Improve the Overall Profile

- Creating awareness especially among parents and children regarding the ill effects of weight gain.
- Promoting regular physical activity through sports and games at schools.
- Consumers could also be educated and encouraged to demand food products of high nutritional quality and safe for consumption.
- School health clubs could be initiated to monitor changes in body weight of children, so as to take up corrective measures at the early stage itself.
- Simple anthropometric measurements for determining weight abnormalities should be popularized (eg. BMI, waist circumference, waist height ratio).
- PTA at schools could be used effectively for information education and communication on obesity management issues.

Further Studies Recommended

- Undernutrition still exists as a major public health problem among the school going children in Kerala. So root cause of the problem needs to be studied in depth to evolve viable strategies taking into consideration of the recent trends in food behavior of children
- Development and standardization of simple field oriented techniques for screening overweight and obesity among children of different age groups, may be done so as to ensure early detection and timely intervention.
- The extent of severity and functional consequences of micronutrient deficiency commonly found among school going children – irrespective of gender and BMI status – may be studied to come out with appropriate remedial measures to overcome it.
- A longitudinal study to track the health implications of childhood obesity and its persistence in adulthood may be undertaken.
- The psychological implications of obesity – the cause and effect relation – need to be studied using modern psychosocial techniques.
- Standard procedures and reference values for diagnosing the relative risks of chronic health problems associated with obesity especially among children and adolescents need to be developed.
- A study to explore the possibilities of integrating obesity management as an essential component of co-curricular / extra-curricular programmes at school to equip the children with necessary knowledge and information on obesity and related aspects, along with training for behavior modification in terms of food and physical activity pattern.

- Many international expert teams are engaged in active research on specific causes or implications of obesity. Similar effort may also be planned in India on a long term basis to deal with obesity problems of regional relevance.

VI. REFERENCES

Aaron, D. J., Storti, K. L., Robertson, R. J., Kriska, A. M. and LaPorte, R. E., 2002. Longitudinal study of the number and choice of leisure time physical activities from mid to late adolescence: implications for school curricula and community recreation programs. *Archives in Pediatric and Adolescent Medicine*, **156**: 1075–80.

Abate, N., 2000. Obesity and cardiovascular disease. Pathogenetic role of the metabolic syndrome and therapeutic implications. *Journal of Diabetes and its Complications*, **14**: 154 –74.

Agras, W. S. and Mascola, A. J. 2005, Risk factors for childhood overweight. *Current Opinion in Pediatrics,* **17**: 648-652.

Allian, C. C. 1995, *Clinical Chemistry,* William Heinemann Medical Books Ltd. London, p. 470.

Allison, D. B., Fontaine, K. R., Manson, J. E., Stevens, J. and Van Itallie, T. B., 1999, Annual deaths attributable to obesity in the United States. *The Journal of the American Medical Association*, **282**:1530–1538.

Alluaim, A. R., Bamgboye, E. A. and Al-Herbish, A., 1996, The pattern of growth and obesity in Saudi Arabian male school children, *International Journal of Obesity Related Metabolic Disorders* **20**: 107-111.

Andersen, R. E., Crespo, C. J., Bartlett, S. J., Cheskin, L. J. and Pratt, M., 1998. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the Third National Health and Nutrition Examination Survey. *Journal of the American Medical Association*, **279**: 938–42.

Annoni, G., Bottasso, B. M., Ciaci, D., Donato, M. F., Tripol, A., 1982, Evaluation of a new enzymatic colorimetric method for triglyceride estimation. *Research Journal of Laboratory Medicine*, **9**: 115.

Anonymous, 2010. India's children and comparison of population sizes, Ministry of women and child development, Government of India. Available at http:// wcd.nic.in.udisha/htm/catalogue/2.doc

Anonymous, 2005, Number of schools in Thrissur district. Department of Education, Government of Kerala. Available at http://thrissur.nic.in/schools.asp

Ardern, C. I., Katzmarzyk, P. T., Janssen, I. and Ross, R. 2003, Discrimination of health risk by combined body mass index and waist circumference. *Obesity Research*, **11**: 135–42.

Ardle, M. W. D., Katch, F. L. and Katch, V. L. 1986, *Exercise , Physiology, Energy, Nutrition and Human Performance,* Lea and Febiger Publishers, Philadelphia, pp. 47-67.

Arenz, S., Rückerl, R., Koletzko, B. and von Kries, R., 2004. Breast-feeding and childhood obesity- A systematic review. *International Journal of Obesity*, **28**: 1247–1256.

Armstrong, J. and Reilly, J. J., 2002, Child Health Information Team. Breastfeeding and lowering the risk of childhood obesity. *Lancet,* **359**: 2003-2004.

Ashwell, M., 1997, The Ashwell Shape Chart- a new millennium approach to communicate the metabolic risks of obesity. *Obesity Research,* **5**: 45S.

Ashwell, M. A., LeJeune, S. R. E. and McPherson, K., 1996, Ratio of waist circumference to height may be better indicator of need for weight management. *British Medical Journal,* **312**: 377.

Ashwell, M. and Hsieh, S.D., 2005, Six reasons why the waist-to-height ratio is arapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *International Journal of Food Sciences and Nutrition,* **56**: 303-307.

Ashwell, M., 1998, The Ashwell Shape Chart- a public health approach to the metabolic risks of obesity. *International Journal of Obesity,* **22** (Supplement 3): S213.

August, G. P., Caprio, S., Fennoy, I., Freemark, M., Kaufman, F. R., Lustig, R. H., Silverstein, J. H., Speiser, P. W., Styne, D. M. and Montori, V. M., 2008. Prevention and treatment of pediatric obesity: An endocrine society clinical practice guideline based on expert opinion. *Journal of Clinical Endocrinology and Metabolism,* **93**: 4576-4599.

Azinge, E. C., Mabayoje, M. and Ward, L. C., 2003, Body proportions in three Nigerian tribes. *Acta Diabetologica,* **40** (Suppl. 1): S317-S319.

Baik, I., Ascherio, A. and Rimm, E. B., 2000, Adiposity and mortality in men. *American Journal Epidemiology,* **152**: 264–71.

Bamji, M.S. 2003, Biochemical tests for the assessment of nutrition status. In: *Text Book of Human Nutrition*. (Eds.) Bamji, M. S., Rao, P. N. and Reddy, V., Oxford and IBH publishing company Pvt. Ltd., New Delhi, pp. 250 -337.

Barlow, S. E. and Dietz, W. H., 1998, Obesity evaluation and treatment: Expert committee recommendations. *Pediatrics,* **102**: E29.

Baughcum, A. E., Chamberlin, L. A., Deeks, C. M., Powers, S. W. and Whitaker, R. C., 2000, Maternal perceptions of overweight preschool children. *Pediatrics,* **106**: 1380–1386.

Becker, D. M., Yanek, L. R., Koffman, D. M. and Bronner, Y. C., 1999, Body image preferences among urban African Americans and whites from low income communities. *Ethnicity and Disease,* **9**: 377– 86.

Beech, B. M., Kumanyika, S. K., Baranowski, T., Davis, M., Robinson, T. N., Sherwood, N. E., Taylor, W. C., Relyea, G., Zhou, A., Pratt, C., Owens, A. and Thompson, N. S., 2004. Parental cultural perspectives in relation to weight-related behaviors and concerns of African-American girls. *Obesity Research,* **12**: 7S–19S.

Bellisle, F., Cachera, R. M. F., Deheeger, M and Guilloud, B. M., 1988. Obesity and food intake in children: evidence for a role of metabolic and/or behavioral daily rhythms. *Appetite,* **11**: 111-118.

Bellizi, M. C. and Dietz, W. H. 1999, Workshop on childhood obesity: summary of the discussion. *American Journal of Clinical Nutrition,* **70**: 173-175.

Bergmann, K E., Bergmann, R. L., von Kries, R., Böhm, O., Richter, R., Dudenhausen, J. W. and Wahn, U., 2003. Early determinants of childhood overweight and adiposity in a birth cohort study: role of breast-feeding. *International Journal of Obesity,* **27**: 162–172.

Berns, M. A., deVries, J. H. and Katan, M. B., 1989. Increase in body fatness as a major determinant of changes in serum total cholesterol and high density lipoprotein cholesterol in young men over a 10-year period. *American Journal of Epidemiology,* **130**: 1109 –1122.

Bertsias, G., Mammas, I., Linardakis, M. and Kafatos, A. 2003, Overweight and obesity in relation to cardiovascular disease risk factors among medical students in Crete, Greece. *BMC Public Health*, **3**: 3.

Bharati, D. R., Deshmukh, P. R. and Garg, B. S., 2008. Correlates of overweight and obesity among scholl going children of Wardha city, Central India. *Indian Journal of Medical Research*, **127**: 539-543.

Bjorntorp, P., 1988, The associations between obesity, adipose tissue distribution and disease. *Acta Medica Scandinavica,* **723**: 121-134.

Blass, E. M., Anderson, D. R., Kirkorian, H. L., Pempek, T. A., Price, I. and Koleini, M.F., 2006. On the road to obesity: Television viewing increases intake of high density foods. *Physiology and Behaviour*, **88**: 597- 604.

Bogen, D. L., Hanusa, B. H. and Whitaker, R. C., 2004. The effect of breast-feeding with and without formula use on the risk of obesity at 4 years of age. *Obesity Research,* **12**: 1527–1535.

Booth, M., Macaskill, P., McLellan, L., Phongsavan, P., Okely, T., Patterson, J., Wright, J., Bauman, A. and Baur, L., 1997. NSW schools fitness and physical activity survey 1997. Ryde, New South Wales, Australia: NSW Department of Education and Training.

Bouchard, C. 1996, Long-term porgramming of body size. *Nutrition Reviews,* **54**: S8 –16.

Brambilla, P., Monzoni, P., Sironi, P., Maschio, D. A., Natale, B. D. and Chiumella, G. 1994, Peripheral and abdominal adiposity in childhood obesity.

International Journal of Obesity and Related Metabolic Disorders, **18**: 795-800.

Brathwaite, N., Fraser, H. S., Modeste, N., Broome, H. and King, R., 2003. Obesity, diabetes, hypertension and vegetarian status among seventh-day adventists in Barbados: Preliminary results. *Ethnicity and Disease*, 13: 34-39.

Brochu, M., Starling, R. D., Tchernof, A., Matthews, D. E., Garcia-Rubi, E. and Poehlman, E. T., 2000, Visceral adipose tissue is an independent correlate of glucose disposal in older obese postmenopausal women. *Journal of Clinical Endocrinology and Metabolism*, **85**: 2378–84.

Bronner, Y. L. 1996, Nutritional status outcomes for children: Ethnic, cultural, and environmental contexts. *Journal of the American Dietetic Association,* **96**: 891-903.

Broussard, B., Sugarman, J. and Bachman-Carter, K., 1995, Toward comprehensive obesity prevention programs in Native American communities. *Obesity Research*, **3**: 289–97S.

Bruch, H. 1941, Obesity in childhood and personality development. *American Journal of Orthopsychiatry*, **11**: 467-474.

BSI, British Standards Institute, 1990, Body measurements of boys and girls from birth to 16 years. BS7321, London.

Buccolo G. and David, M. 1973, Quantitative determination of plasma triglycerides by the use of enzymes. *Clinical Chemistry*, **19**: 476 – 482.

Buchholz, A. C., Bartok, C. and Schoeller, D. A. 2004, The validity of bioelectrical impedance models in clinical populations. *Nutrition in Clinical Practice*, **19**: 433-446.

Bundred, P., Kitchiner, D. and Buchan, I., 2001, Prevalence of overweight and obese children between 1989 and 1998: Population based series of cross sectional studies. *British Medical Journal*, **322**: 326–328.

Burns, S. P., Desai, M., Cohen, R. D., Hales, C. N., Iles, R. A., Germain, J. P., *et al*. 1997. Gluconeogenesis, glucose handling, and structural changes in livers of the adult offspring of rats partially deprived of protein during pregnancy and lactation. *Journal of Clinical Investigation*, **100**: 1768-74.

Burton, W. N., Chen, C.Y., Schultz, A. B. and Edington, D.W., 1998, The economic costs associated with body mass index in a work place. *Journal of Occupational and Environmental Medicine*, **40**: 786-792.

Butryn, M. L. and Wadden, T. A. 2005, Treatment of overweight in children and adolescents: Does dieting increase the risk of eating disorders? *International Journal of Eating Disorders*, **37**: 285-293.

Butte, N. F., 2001, The role of breastfeeding in obesity. *Pediatric Clinics of North America*, **48**: 189-198.

Butte, N. F., Christiansen, E. and Sørensen, T. A., 2007, Energy imbalance underlying the development of childhood obesity. *Obesity*, **15**: 3056 –3066.

Butte, N. F., Wong, W. W., Hopkinson, J. M., Smith, E. O. and Ellis, K. J., 2000, Infant feeding mode affects early growth and body composition. *Pediatrics*, **106**: 1355-1366.

Caballero, B., Davis, S., Davis, C., 1998. Pathways: a schoolbased program for the primary prevention of obesity in American Indian children. *Journal of Nutritional Biochemistry*. **9**: 535– 43.

Cachera, R. M. F, Deheeger, M. and Bellisle, F., 1996, Nutrient balance and android body fat distribution: why not a role for protein? *American Journal of Clinical Nutrition* 64:663-4.

Cachera, R. M. F., Sempe, M., Bataille, G. M., Patois, E., Guggenbuhl, P. F., Fautrad, V., 1982, Adiposity indices in children. *American Journal of Clinical Nutrition*, **36**: 178-84.

Cachera, R. M. F., Deheeger, M., Akrout, M. and Bellisle, F., 1995, Influence of macronutrients on adiposity development: a follow up study of nutrition and growth from 10 months to 8 years of age. *International Journal of Obesity and Related Metabolic Disorders,* **19**: 573-8.

Cachera, R. M. F., Deheeger, M., Bellisle, F., Sempé, F., Guilloud-Bataille, M. and Patois, E., 1984, Adiposity rebound in children: a simple indicator for predicting obesity. *American Journal of Clinical Nutrition*, **39**: 129-135.

Callahan, S. T. and Mansfield, M. J., 2000, Type II diabetes mellitus in adolescents. *Current Opinion in Paediatrics,* **12**: 310–315.

Calle, E. E., Thun, M. J., Petrelli, J. M., Rodrigues, C. and Heath, C. W., 1999, Body-mass index and mortality in a prospective cohort of US adults. *New England Journal of Medicine,* **341**: 1097–1105.

Canning, H. and Mayer, J. 1966, Obesity: its possible effect on college acceptance. *New England Journal of Medicine*, **275**: 1172– 4.

Carey, V., Walters, E. and Colditz, G., 1997, Body fat distribution and risk of non-insulin-dependent diabetes in women. *American Journal of Epidemiology*, **145**: 614–619.

Carter, V., Good, E. and Douglas, E. S. 1987, *Methods of Research*, Mc.Millan Publishing Company, New York, pp. 670.

CDC, Centers for Disease Control and Prevention, 1996, Asthma mortality and hospitalization among children and young adults—United States, 1980-1993. *Morbidity and Mortality Weekly Report*, **45**: 350-353.

CDC, Centers for Disease Control and Prevention, 1998, Surveillance for asthma—United States, 1960-1995. In: *CDC Surveillance Summaries*, April 1998. *Morbidity and Mortality Weekly Report*, **47**: SS-1.

CDC, Centers for Disease Control and Prevention, 2000, Measuring childhood asthma prevalence before and after the 1997 redesign of the National Health Interview Survey-United States. *Morbidity and Mortality Weekly Report*, **49**: 908-911.

CDC, Centres for Disease Control and Prevention, 1997, Prevalence of overweight among children, adolescents, and adults: United States, 1988-1994. *Morbidity and Mortality Weekly Report,* **46**: 199–202.

CDC, Centres for Disease Control and Prevention, 2009, Obesity percentile calculator. Available at http://apps.nccd.cdc.gov/dnpabmi/Result.aspx retrieved on 09.07.2009.

Chan, J. M., Rimm, E. B., Colditz, G. A., Stampfer, M. J. and Willett, W. C., 1994, Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. *Diabetes Care,* **17**: 961–969.

Chang, C., Wu, C., Chang, C., Yao, W., Yang, Y., Wu, J. and Lu, F., 2003, Low body mass index but high percent body fat in Taiwanese subjects: implications of obesity cut-off. *International Journal of Obesity Related Metabolic Disorders*, **27**: 253–259.

Chang, V. W. and Lauderdale, D. S., 2005. Income disparities in BMI and obesity in US. 1971-2002. *Archives of Internal Medicine,* **165**: 2122-2128.

Chaturvedi, S., Kapil, U., Ganasekaran, N., Sachdev, H. P.S., Pandey, R.M. and Bhanli, T., 1996, Nutrient intake among adolescent girls belonging to poor socio economic group of rural area of Rajasthan. *Indian journal of Paediatrics,* **33** (3): 197-201.

Chen, M. and Asami, T., 1987. Chino-Japanese cooperative study on physical fitness of children and youth, II. Tokyo: Sports Science Committee, Japan Amateur Sports Association, (in Japanese).

Chen, M. M., Lear, S. A., Gao, M., Frohlich J. J. and Birmingham, C. L., 2001, Intraobserver and Interobserver Reliability of Waist Circumference and the Waist-to-Hip Ratio. *Obesity Research,* **9**: 651.

Chhatwal, J., Verma, M. and Kaur, R., 2004, Obesity among pre-adolescent and adolescents of a developing country (India). *Asia Pacific Journal of Clinical Nutrition,* **13**: 231-235.

Chinn, S., 2003, Obesity and asthma: evidence for and against a causal relation. *Journal of Asthma,* **40**: 1-16.

Chinn, S., 2006, Obesity and asthma. *Pediatric Respiratory Reviews*, **7**: 223-228.

Chinn, S. and Rona, R. J., 1994, Trends in weight-for-height and triceps skinfold thick-ness in English and Scottish children 1972-82 and 1982-90. *Paediatr Peri-natal Epidemiology,* **8**: 90-109.

Chinn, S. and Rona, R.J., 2001, Prevalence and trends in overweight and obesity in three cross sectional studies of British children, 1974-94. *British Medical Journal,* **322**: 24-26.

Chu, N. F., Rimm, E. B., Wang, D. J., Liou, H. S, Shieh, S. M. 1998. Clustering of cardiovascular disease risk factors among obese schoolchildren: the Taipei Children Heart Study. *American Journal of Clinical Nutrition*. **67**:1141– 6.

Chumlea, W. C., Guo, S. S., Kuczmarski, R. J., Flegal, K. M., Johnson, C. L., Heymsfield, S. B., Lukaski, H. C., Friedl, K. and Hubbard, V. S., 2002. Body composition estimates from NHANES III bioelectrical impedance data. *International Journal of Obesity Related Metabolic Disorders*, **26**: 1596–609.

Clifford, T. J., 2003. Breast feeding and obesity. *British Medical Journal*, **327**: 879-880.

Cole, T. J., Bellizi, M. C., Flegal, K. M. and Dietz, W. H., 2000, Establishing a standard definition for child overweight and obesity worldwide: An international survey. *British Medical Journal,* **320**: 1240-3.

Cole, T. J. and Cachera, R. M. F., 2002, Child and adolescent obesity: Causes and consequences, Prevention and management. In: Measurement and Definition, Eds. Burniat, W., Cole, T. J., Lissau, I. and Poskitt, E. M. E., Cambridge University Press, UK, pp.25-49.

Committee on the Surveillance Project on the Condition of Children's Health, 1998, *The Report on the Surveillance Project on the Condition of Children's*

Health, [in Japanese]. Tokyo, Japan, The Japanese Society of School Health, 1997.

Comuzzie, A. G. and Allison, D. B. 1998, The search for human obesity genes. *Science*. **280**: 1374 –1377.

Coon, K. A., Goldberg, J., Rogers, B. L. and Tucker, K. L., 2001, Relationships between use of television during meals and children's food consumption patterns. *Pediatrics*, **107**: E7.

Cornier, M., Andre, M., Tate, C. W., Grunwald, G. W. and Daniel, H., 2002, Relationship between waist circumference, body mass index, and medical care costs. *Obesity Research*, **10**: 1167–1172.

Cox, B. D. and Whichelow, M. 1996, Ratio of waist circumference to height is better predictor of death than body mass index. *British Medical Journal*, **313**: 1487.

Cox, B. D., Whichelow, M. J., Ashwell, M. A. and Prevost, A. T., 1996, Comparison of anthropometric indices as predictors of mortality in British adults. *International Journal Obesity Related Metabolic Disorders*, **20** (Suppl 4): 141.

Crandall, C. S. 1991, Do heavy-weight students have more difficulty paying for college? *Personality and Social Psychology Bulletin*, **17**: 606 –11.

Crawford, D. A., Timperio, A. F., Salmon, J. A., Baur, L., Billie, G. C., Roberts, R. J., Jackson, M. L., Andrianopoulos, N. M. and Ball, K., 2008. Neighborhood fast food outlets and obesity in children and adults: the CLAN Study. *International Journal of Paediatric Obesity*, **3**: 249-256.

Crawford, D. A., Timperio, A. F., Salmon, J. A., Baur, L., Corti, B. G., Roberts, R. J., Jackson, M. L., Andrianopoulos, N., and Ball, K., 2009. Neighbourhood fast food outlets and obesity in children and adults: the CLAN Study. *International Journal of Paediatrics,* **3**: 249-256.

Crawford, P. B., Obarzanek, E. and Schreiber, G. B., 1995, The effects of race, household income, and parental education on nutrient intakes of 9 and 10 year-old girls: NHLBI Growth and Health Study. *Annals of Epidemiology,* **5**: 360–368.

Crespo, C. J., Smit, E., Troiano, R. P., Bartlett, S. J., Mascera, C. A. and Andersen, R. E., 2001. Television watching, energy intake, and obesity in US children. *Archives in Pediatric and Adolescent Medicine,* **155**: 360–5.

Curhan, G. C., Chertow, G. M., Willett, W. C., Spiegelman, D., Colditz, G. A. and Manson, J. E., 1996, Birth weight and adult hypertension and obesity in women. *Circulation,* **94**: 1310-1315.

Daee, A., Robinson, P., Lawson, M., Turpin, J. A., Gregory, B. and Tobias, J. D. 2002, Psychologic and physiologic effects of dieting in adolescents. *Southern Medical Journal,* **95**:1032-1041.

Dagenais, G. R., Yi, Q., Mann, J. F., Bosch, J., Pogue, J. and Yusuf, S., 2005. Prognostic impact of body weight and abdominal obesity in women and men with cardiovascular disease. *American Heart Journal,* **149**: 54-60.

Daniels, S. R., Khourty, P. R. and Morrison, J. A., 2000, Utility of different measures of body fat distribution in children and adolescents. *American Journal of Epidemiology,* 152: 1179-84.

Daniels, S. R., Khoury, P. R. and Morrison, J. A., 1997, The validity of BMI as a measure of fatness in children and adolescents: differences by race and gender. *Pediatrics,* **99**: 804–807.

Daniels, S. R., Morrison, J. A., Sprecher, D. L., Khoury P. and Kimball, T. R., 1999, Association of body fat distribution and cardiovascular risk factors in children and adolescents. *Circulation,* **99**: 541-545.

Danielzik, S., Czerwinski-Mast, M., Langnäse, K., Dilba, B. and Müller, M. J., 2004, Parental overweight, socioeconomic status and high birth weight are the major determinants of overweight and obesity in 5–7 y-old children: baseline data of the Kiel Obesity Prevention Study (KOPS). *International Journal of Obesity,* **28**: 1494–1502.

Darmon, N., Ferguson, E.L. and Briend, A., 2002. A cost constraint alone has adverse effects on food selection and nutrient density: an analysis of human diets by linear programming. *Journal of Nutrition*, **132**: 3764–3771.

David, J. N., Weigensberg, M. J., Shaibi, G. Q., Crespo, N. C., Kelly, L. A., Lane, C. J. and Goran, M. I., 2007. Influence of breastfeeding on obesity and Type 2 diabetes risk factors in latino youth with a family history of Type 2 diabetes. *Diabetes Care*, **30**: 784-789.

Davis, M. E. J., Rifas-Shiman, S. L., Zhou, L., Hu, F. B., Colditz, G. A. and Gillman, M. W., 2006. Breast-feeding and risk for childhood obesity. Does maternal diabetes or obesity status matter? *Diabetes Care,* **29**: 2231-2237.

Davison, K. K. and Birch, L. L., 2001. Childhood overweight: a contextual model and recommendations for future research. *Obesity Reviews,* **2**: 159–171.

Deheeger, M., Akrout, M., Bellisle, F., Rossignol, C. and Cachera, R.M.F. 1996. Individual patterns of food intake development in children: a 10 months to 8 years of age follow-up study of nutrition and growth. *Physiol Behav* 59:403-7.

Deheeger, M., Akrout, M., Bellisle, F., Rossignol, C. and Rolland-Cachera, M. F., 1996. Individual patterns of food intake development in children: a 10 months to 8 years of age follow-up study of nutrition and growth. *Physiol Behaviour,* **59**: 403-7.

Dehghan, M., Akhtar-Danesh, N. and Merchant, A. T., 2005, Childhood obesity, prevalence and prevention. *Nutrition Journal,* **4**: 24-31.

Dennison, B. A., Edmunds, L. S., Stratton, H. H. and Pruzek, R. M. 2006, Rapid infant weight gain predicts childhood overweight. *Obesity,* **14**: 491– 499.

Dentali, F., Sharma, A. M. and Douketis, J. D., 2005, Management of hyper tension in overweight and obese patients: a practical guide for clinicians. *Current Hypertension Reports,* **7**: 330-336.

Desai, M. and Hales, C. N., 1997. Role of fetal and infant growth in programming metabolism in later life. *Biological Reviews of the Cambridge Philosophical Society,* **72**: 329-48.

Desai, M., Byrne, C. D., Zhang, J., Petry, C. J., Lucas, A. and Hales, C. N., 1997. Programming of hepatic insulin-sensitive enzymes in offspring of rat dams fed a protein-restricted diet. *American Journal of Physiology,* **272**: G1083-90.

Despre's, J. P., 2001, Health consequences of visceral obesity. *Annals of Medicine,* **33**: 534-541.

Despre's, J., Moorjani, S., Lupien, P. J., Tremblay, A., Nadeau, A. and Bouchard, C., 1990, Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. *Arteriosclerosis*, **10**: 497-511.

Deurenberg, P., 2001, Universal cut-off BMI points for obesity are not appropriate. *British Journal of Nutrition*, **85**: 135– 6.

Deurenberg, P., Deurenberg-Yap, M. and Guricci, S., 2002a, Asians are different from Caucasians and from each other in their body mass index/body fat percent relationship. *Obesity Reviews*, **3**: 141–146.

Deurenberg, P., Deurenberg-Yap, M. and Schouten, F. J., 2002b, Validity of total and segmental impedence measurements for prediction of body composition across ethnic population groups. *European journal of Clinical Nutrition*, **56**: 214-220.

Deurenberg, P., Pieters, J. J. and Hautvast, J. G., 1990. The assessment of the body fat percentage by skinfold thickness measurements in childhood and young adolescence. *British Journal of Nutrition*, **63**: 293-303.

Deurenberg, P., Weststrate, A .J. and Seidell, J. C. 1989, Body mass index as a measure of body fatness: age and sex specific prediction formulas. *British Journal of Nutrition*, **65**: 105-114.

Devadas, R. P., 1994. Empowering women towards improving family nutrition. *Proceedings of Nutrition Society of India*, **41**: 85-105.

Devi , L. N., 2000. Nutritional and health impact of substituting green gram by soya products in school lunch programme in Thrissur District. M. Sc. (Home Science) Thesis, Kerala Agricultural University, Thrissur, India, pp. 120.

Dewey, K. G., 2003. Is breastfeeding protective against child obesity? *Journal of Human Lactation*, **19**: 9-18.

Dietz, W. H. 1998a, Health consequences of obesity in youth: Childhood predictors of adult disease. *Pediatrics,* **101**: 518-525.

Dietz, W. H. 1998b, Childhood weight affects adult morbidity and mortality. *Journal of Nutrition*, **128** (2 Suppl): 411S-414S.

Dietz, W. H. and Gortmaker, S. L., 1985, Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. *Pediatrics*, **75**: 807-812.

Dietz, W. H. and Robinson, T. N., 1998, Use of the body mass index (BMI) as a measure of overweight in children and adolescents. *Journal of Pediatrics,* **132**: 191-3.

Dietz, W. H., 1993, Television, obesity and eating disorders. *Adolescent Medicine,* **4**: 543–50.

Dietz, W. H., 2001a, Overweight and precursors of type 2 diabetes mellitus in children and adolescents. *Journal of Pediatrics,* **138**: 453–454.

Dietz, W. H., 2001b, Breastfeeding may help prevent childhood overweight. *The Journal of the American Medical Association,* **285**: 2506-2507.

Dietz, W.H., 1994, Critical periods in childhood for the development of obesity. *American Journal of Clinical Nutrition,* **59**: 955-959.

Dietz, W.H., 2004, Overweight in childhood and adolescence. *New England Journal of Medicine,* **350**: 855 – 857.

Divakar, M. V., Bhatt and Mulla, A., 1978. Effect of Yoga therapy in diabetes and obesity. *Journal of Diabetic Association of India*, **18**: 75-78.

Dobbelsteyn, C. J., Joffres, M. R., MacLean, D. R. and Flowerdew, G., 2001, A comparative evaluation of waist circumference, waist-to-hip ratio and body mass index as indicators of cardiovascular risk factors. *International Journal of Obesity Related Metabolic Disorders,* **25**: 652–661.

Drewnowski, A., 1998. Energy density, palatability, and satiety: implications for weight control. *Nutrition Reviews,* **6**: 347–353.

Drewnowski, A., 2007. The real contribution of added sugars and fats to obesity. *Epidemiological Reviews,* **29**: 160–171.

Drewnowski, A., 2009. Obesity, diets, and social inequalities. *Nutrition Reviews.* **67**: S36–39.

Drewnowski, A., Darmon, N. and Briend, A., 2004. Replacing fats and sweets with vegetables and fruit – a question of cost. *American Journal of Public Health,* **94**: 1555–1559.

Dunger, D., Ahmed, M. L. and Ong, K. 2005, Effects of obesity on growth and puberty. *Best Practice & Research Clinical Endocrinology & Metabolism,* **19**: 375-390.

Dwyer, J. T., Andrews, E. M., Valadian, I. and Reed, R. B., 1980. Size, obesity and leanness in vegetarian preschool children. *Journal of the American Dietetic Association*, **77**: 434-9.

Dwyer, J. T., Coonan, W. E., Leitch, D. R., Hetzel, B. S. and Baghurst, R. A., 1983, An investigation of the effects of daily physical activity on the health of primary school students in South Australia. *International Journal of Epidemiology,* **12**: 308–13.

Ebling, F. 2003, Puberty: mind and body. *Journal of Neuroendocrinology,* **15**: 323-324.

Eisenberg, M. E., Neumark-Sztainer, D. and Story, M. 2003, Associations of weight-based teasing and emotional well-being among adolescents. *Archives in Pediatric and Adolescent Medicine,* **157**: 733– 8.

Eisenmann, J. C., Heelean, K. A., Welk, G. J., 2004. Assessing body composition among 3-to 8-year-old children: anthropometry, BIA, and DXA. Obesity Research, **12**: 1633-40.

Elberg, J., McDuffie, J. R., Sebring, N. G., Salaita, C., Keil, M., Robotham, D., Reynolds, J. C. and Yanovski, J. A., 2004, Comparison of methods to assess change in children's body composition. *American Journal of Clinical Nutrition,* **80**: 64 –9.

Ellis, K. J., Abrams, S. A. and Wong, W. W., 1999, Monitoring childhood obesity: assessment of the weight/height2 index. *American Journal of Epidemiology,* **150**: 939–946.

Epstein, L. H., 1996, Family-based behavioural intervention for obese children. *International Journal of Obesity Related Metabolic Disorders,* **20**: S14–21.

Epstein, L. H., Gordy, C. C., Raynor, H. A., Beddome, M., Kilanowski, C. K. and Paluch, R. 2001, Increasing fruit and vegetable intake and decreasing fat and sugar intake in families at risk for childhood obesity. *Obesity Research,* **9**: 171–178.

Epstein, L. H., Wing, R. R. and Valoski, A., 1985, Childhood obesity. *Pediatric Clinics of North America,* **32**: 363–79.

Faith, M. S., Berman, N, Heo, M., Pietrobelli, A., Gallagher, D., Epstein, L. H, Eiden, M. T. and Allison, D.B. 2001. Effects of contingent television on physical activity and television viewing in obese children. *Pediatrics*, **107**: 1043-1048.

Fall, C. H., Osmond, C., Barker, D. J., Clark, P. M., Hales, C. N. and Stirling, Y., 1995, Fetal and infant growth and cardiovascular risk factors in women. *British Medical Journal,* **310**: 428-432.

Farooqi, I. 2005, Genetic and hereditary aspects of childhood obesity. *Best Practice & Research Clinical Endocrinology & Metabolism,* **19**: 359-374.

Feldman, W., 1994, Periodic health examination, 1994 update: 1.Obesity in childhood. Canadian Task Force on the Periodic Health Examination. *Canadian Medical Association Journal,* **150**: 871–879.

Field, A. E., Laird, N., Steinberg, E., Fallon, E., Semega-Janneh, M. and Yanovski, J. A., 2003. Which metric of relative weight best captures body fatness in children? *Obesity Research,* **11**: 1345–1352.

Field, A. E., Nancy, R. C., and Matthew, W. G., 2005.Weight status in childhood as a predictor of becoming overweight or hypertensive in early adulthood. *Obesity Research.* **13**: 163–169.

Fisher, A., Reilly, J. J., Montgomery, C., Williamson, A., Paton, J. Y. and Grant, S., 2005. Fundamental movement skills and habitual physical activity in young children. *Medicine and Science in Sports and Exercise,* **37**: 684-8.

Flegal, K. M., Carroll, M. D., Kucsmarski, R. J. and Johnson, C. L., 1998, Overweight and obesity in the United States: Prevalence and trends. 1960-1994. *International Journal of Obesity Related Metabolic Disorders,* **22**: 39–47.

Flegal, K. M., Carroll, M. D., Ogden, C. L., Johnson, C. L. 2002a, Prevalence and trends in obesity among US adults, 1999-2000. *Journal of the American Medical Association,* **288**: 1723-1727.

Flegal, K. M., Wei, R. and Ogden, C. 2002b, Weight-for-stature compared with body mass index-for-age growth charts for the United States from the Centers for Disease Control and Prevention. *American Journal of Clinical Nutrition,* **75**: 761-766.

Flodmark, C. E. 2005, The happy obese child. *International Journal of Obesity,* **29**: S31-S33.

Flodmark, C. E., Lissau, I., Moreno, L. A., Pietrobelli, A. and Widhalm, K., 2004, New insights into the field of children and adolescents' obesity: the European perspective. *International Journal of Obesity,* **28**: 1189.

Flodmark, C. E., Sveger, T. and Nilsson-Ehle, P., 1994, Waist measurement correlates to a potentially atherogenic lipoprotein Profile in obese 12-14 y old children. *Acta Paediatica,* **83**: 941-945.

Flores, R., 1995, Dance for health: Improving fitness in African-American and Hispanic adolescents. *Public Health Reports,* **110**: 189–193.

Flynn, M. A. T., McNeil, D. A., Maloff, B., Mutasingwa, D., Wu, M., Ford, C. and Tough, S. C., 2006, Reducing obesity and related chronic disease risk in children and youth: a synthesis of evidence with 'best practice' recommendations. *Obesity Reviews,* **7**: 7-66.

Fogelholm, M. and Lichtenbelt, M. W. 1997, Comparison of body composition methods: a literature analysis. *European Journal of Clinical Nutrition,* **51**: 495–503.

Folsom, A. R., Kaye, S. A. and Sellers, T. A., 1993, Body fat distribution and 5-year risk of death in older women. The *Journal of the American Medical Association*, **269**: 483–487.

Forbes, G. B. 1987, *Human Body Composition*. Springer Verlarg, New York, pp.150.

Ford, B. S., McDonald, T. E., Owens, A. S. and Robinson, T. N., 2002. Primary care interventions to reduce television viewing in African American children. *American Journal of Preventive Medicine,* **22**: 106–9.

Ford, E. S., Giles, W. H. and Dietz, W. H., 2002, Prevalence of the metabolic syndrome among U.S. adults: findings from the Third National Health and Nutrition Examination Survey. *The Journal of the American Medical Association*, **287**: 356–359.

Fox, K., Peters, D., Armstrong, N., Sharpe, P. and Bell, M., 1993. Abdominal fat deposition in 11y old children. *International Journal of Obesity Related Metabolic Disorders,* **17**: 11-16.

Francis, L. A., Lee, Y. and Birch, L. L., 2003, Parental weight status and girls television viewing, snacking and body mass indexes. *Obesity Research,* **1**: 143-151.

Franklin, M. F., 1999, Comparison of weight and height relations in boys from 4 countries. *American Journal of Clinical Nutrition*, **70**: 157-162

Frayne, K. N., 2000, Visceral fat and insulin resistance-causitive or correlative? *British Journal Nutrition*, **83**: S71–7.

Freedman, D. S., 1997, Secular increases in relative weight and adiposity among children over two decades; the Bolgousa Heart study. *Pediatrics*, **99**: 420-426.

Freedman, D. S., Dietz, W. H., Srinavasan, S. R. and Berenson, G. S., 1999, The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics*, **103**: 1175–1182.

Freedman, D. S., Khan, L. K., Dietz, W. H., Srinivasan, S. R. and Berenson, G. S., 2001. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa Heart Study. *Pediatrics*, **108**: 712– 718.

Freedman, D. S., Serdula, M. K., Srinivasan, S. R. and Berenson, G. S., 1999. Relation of circumferences and skin-fold thicknesses to lipid and insulin concentrations in children and adolescents: the Bogalusa Heart Study. *American Journal of Clinical Nutrition*, **69**: 308-317.

French, S., Story, M. and Perry, C. 1995, Self-esteem and obesity in children and adolescents: a literature review. *Obesity Research*, **3**: 479-490.

Friedewald, W. T., Levy, R. I. and Federickson, D. 1972, Estimation of the concentration of low density lipoprotein cholesterol in plasma without use of the preparative ultra centrifugation. *Clinical Chemistry*, **18**: 499 -502.

Friedland, O., Nemet, D., Gorodnitsky, N., Wolach, B. and Eliakim, A. 2005, Obesity and lipid profiles in children and adolescents. *Journal of Pediatric Endocrinology and Metabolism*, **15**: 1011– 6.

Friedman, L. S., Lukyanova, E. M., Serdiuk, A., Nizhnyk, Z. A. S., Chislovska, N. V., Zvinchuk, A. V., Oliynyk, I. and Hryhorczuk, D., 2009, Social-environmental factors associated with elevated body mass index in a Ukrainian cohort of children. *International Journal of Paediatric Obesity,* **4**: 81–90.

Friedman, M. and Brownell, K. 1995, Psychological correlates of obesity: moving to the next research generation. *Psychological Bulletin* **117**: 3-20.

Frontini, M. G., Bao, W., Elkasabany, A., Srinivasan, S. R. and Berenson G., 2001, Comparison of weight-for-height indices as a measure of adiposity and cardiovascular risk from childhood to young adulthood: The Bogalusa heart study. *Journal of Clinical Epidemiology*, **54**: 817–822.

Fujimoto, W. Y., Bergstrom, R. W. and Boyko, E. J., 1999, Visceral adiposity and incident coronary heart disease in Japanese-American men. *Diabetes Care,* **22**: 1808–1812.

Fulton, J. E., McGuire, M. T., Caspersen, C. J. and Dietz, W. H. 2001, Interventions for weight loss and weight gain prevention among youth – Current issues. *Sports Medicine,* **31**: 153-165.

Garce´s, C., Benavente, M., Ortega, H., et al. 2002. Influence of birth weight on the Apo E genetic determinants of plasma lipid levels in children. *Pediatric Research,* 52: 873– 8.

Garce´s, C., Gutierrez-guisado, J., Benavente, M., Cano, B., Viturro, E., Ortega, H. and Manuel, D. O. 2005, Obesity in Spanish schoolchildren: relationship with lipid profile and insulin resistance. *Obesity Research*, **13**: 959 –963.

Garcia, A. L., Wagner, K., Hothorn, T., Koebnick, C., Zunft, H. F. and Trippo, U. 2005, Improved prediction of body fat by measuring skinfold thickness, circumferences, and bone breadths. *Obesity Research*, **13**: 626–634.

Garcia-Marcos, L., Valverde-Molina, J., Ortega, C. M. L., Sanchez-Solis, M., Martinez-Torres, A. E. and Castro-Rodríguez, J. A., 2008, Percent body fat, skinfold thickness or body mass index for defining obesity or overweight, as a risk factor for asthma in schoolchildren: which one to use in epidemiological studies? *Maternal and Child Nutrition,* **4**: 304-310.

Garrow, J. S. 2000, Checklist for the methods of selection of dietary investigations. In: *Human Nutrition and Dietetics*. 10th Ed., Garrow, J. S., James, W. P. T. and Ralph. (Eds.), Aharcout Publishers Ltd., pp. 327–331.

Garrow, J. S., 1981, *Treat Obesity Seriously - a clinical manual*. Churchill Livingstone, Edinburgh.

Geetha, S., 2003. Prevalence of obesity in high school girls of Trivandrum District, Kerala. M. Phil. Thesis (Clinical Epidemiology), Kerala University. Thrivandrum.

Ghosh, R. M., 1997. Health care under fires. *Home Science*. **15**: 7-10.

Giammattei, J., Blix, G., Marshak, H. H., Wollitzer, A. O. and Pettitt, D. J., 2003. Television watching and soft drink consumption: Associations with obesity in 11-13 year old school children. *Archives of Paediatrics and Adolescent Medicine*, 157: 882-886.

Gillman, M. W. and Cook, N. R. 1995. Blood pressure measurement in childhood epidemiological studies. *Circulation*. **92**: 1049–57.

Gillman, M. W., Rifas-Shiman, S. L., Camargo, C. A. Jr., Berkey, C. S., Frazier, A. L., Rockett, H. R. H., Field, A. E. and Colditz, G. A., 2001. Risk of overweight among adolescents who were breastfed as infants. *Journal of the American Medical Association*, **285**: 2461-2467.

Gillman, M. W., Rifas-Shiman, S., Berkey, C. S., Field, A. E. and Colditz, G. A., 2003, Maternal gestational diabetes, birth weight, and adolescent obesity. *Pediatrics*, **111**: e221-e226.

Gittelsohn, J., Wolever, T. M., Harris, S. B., Harris-Giraldo, R., Hanley, A. J. and Zinman, B. 1998, Specific patterns of food consumption and preparation are associated with diabetes and obesity in a Native Canadian community. *Journal of Nutrition,* **128:** 541-547.

Gnavi, R., Spagnoli, T. D., Galotto, C., Pugliese, E., Carta, A. and Cesari, L., 2000, Socio-economic status, overweight and obesity in prepuberal children: a study in an area of Northern Italy. *European Journal of Epidemiology,* **16**: 797– 803.

Goindi, G., Kapil, U. and Singh, P., 2003, Obese kids and nutrition disorders. *Food and Nutrition World,* **21**: 1.

Going, S. B., Thompson, J., Cano, S., et al. 2003. The effects of the Pathways Obesity Prevention Program on physical activity in American Indian children. *Preventive Medicine,* **37**(suppl): 62–9S.

Gold, D. R., Damokosh, A. I., Dockery, D. W. and Berkey, C. S., 2003, Bodymass index as a predictor of incident asthma in a prospective cohort of children. *Pediatric Pulmonology,* **36**: 514 –521.

Gomez, F., Ramos, G. R., Frenk, S., Carvioto, T., Charez, R. and Vazquex, J. 1956, Mortality is second and third degree malnutrition. *Journal of Tropical Paediatrics,* **2**: 77-83.

Goodman, E. and Whitaker, R.C., 2002. A prospective study of the role of depression in the development and persistence of adolescent obesity. *Pediatrics,* **109**: 497-504.

Goodpaster, B. H., Thaete, F. L., Simoneau, J. A. and Kelley, D. E., 1997, Subcutaneous abdominal fat and thigh muscle composition predict insulin sensitivity independently of visceral fat. *Diabetes,* **46**: 1579–85.

Goran, M. I., 1998, Measurement issues related to studies of childhood obesity: assessment of body composition, body fat distribution, physical activity, and food intake. *Pediatrics,* **101**: 505-18.

Goran, M. I., 2001. Metabolic precursors and effects of obesity in children: a decade of progress, 1990–1999. *American Journal of Clinical Nutrition,* **73**: 158-171.

Goran, M. I., Bergman, R. N., Cruz, M. L. and Watanabe, R., 2002. Insulin resistance and associated compensatory responses in African- American and Hispanic children. *Diabetes Care,* **25**: 2184–2190.

Goran, M. I., Gower, B. A., Treuth, M. and Nagy, T. R., 1998. Prediction of intra-abdominal and subcutaneous abdominal adipose tissue in healthy pre-pubertal children. *International Journal of Obesity Related Metabolic Disorders*, **22**: 549-58.

Gordon, T., Castelli, W. P., Hjortland, M. C., Kannel, W. V., Dawber, T. R., 1977, High density lipoprotein as a protective factor against coronary heart disease. The Framingham study. *American Journal of Medicine*, **62**: 707-714.

Gortmaker, S. L., Must, A., Perrin, J. M., Sobol, A. M. and Dietz, W. H., 1993, Social and economic consequences of overweight in adolescents and young adulthood. *New England Journal of Medicine*, **329**: 1008-1012.

Gortmaker, S. L., Must, A., Sobol, A. M., Petgerson, K., Colditz, G. A. and Dietz, W. H., 1996, Television viewing as a cause of increasing obesity among children in the United States 1986-1990. *Archives of Pediatrics and Adolescent Medicine*, **150**: 356-362.

Gortmaker, S. L., Peterson, K. and Wiecha, J., 1999, Reducing obesity via a school-based interdisciplinary intervention among youth. *Archives of Pediatrics and Adolescent Medicine*, **153**: 409–418.

Grummer-Strawn, L. M. and Mei, Z., 2004, Does breastfeeding protect against pediatric overweight? Analysis of longitudinal data from the centers for disease control and prevention pediatric nutrition surveillance system. *Pediatrics*, **113**: e81-86.

Grunwald, G. K. and Daniel, H. B., 2002, Relationship between waist circumference, body mass index and medical care costs. *Obesity Research*, **10**: 1167-1172.

Gunderson, E. P., 2007. Breastfeeding after gestational diabetes pregnancy: Subsequent obesity and Type 2 diabetes in women and their offspring. *Diabetes Care*, **30**: S161-S168.

Guo, S. S., Roche, A. F., Chumlea, W. C., Gardner, J. D. and Siervogel, R. M., 1994, The predictive value of childhood body mass index values for overweight at age 35 y. *American Journal of Clinical Nutrition*, **59**: 810–819.

Gupta, R., Gupta, V. P., Prakash, H., Sarna, M. and Gupta, K. D. 2003, Serial epidemiological suveys in an urban Indian population demonstrate increasing coronary risk factors among the lower socio economic strata. *Journal of Association of Physicians of India,* **51**: 470 -477.

Gurung, R. A. and Mehta, V., 2001, Relating ethnic identity, acculturation,and attitudes toward treating minority clients. *Cultural Diversity and Ethnic Minority Psychology*, **7**: 139–151.

Haarbo, J., Hassager, C., Riis, B. J. and Christensen, C., 1989. Relation of body fat distribution to serum lipids and lipoproteins in elderly women. *Atherosclerosis,* **80**: 57– 62.

Haarbo, J., Hassager, C., Schlemer, A. and Christiansen, C., 1990. Influence of smoking, body fat distribution and alcohol consumption on serum lipids, lipoproteins and apolipoproteins in early postmenopausal women. *Atherosclerosis,* **84**: 239 –244.

Hall, D. M., 2002, *Health for All Children: Report of the Fourth Joint Working Party on Child Health Surveillance*. Oxford, United Kingdom: Oxford University Press.

Han, T. S., Bijnen, F. C. H., Lean, M. E. J. and Seidell, J. C., 1998. Separate associations of waist and hip circumference with lifestyle factors. *International Journal of Epidemiology,* **27**: 422–30.

Han, T. S., McNeill, G., Seidell, J. C. and Lean, M. E., 1997, Predicting intra-abdominal fatness from anthropometric measures: the influence of stature. *International Journal of Obesity Related Metabolic Disorders*, **21**: 587– 593.

Han, T. S., van Leer, E. M., Seidell, J. C. and Lean, M. E., 1995, Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. *British Medical Journal*, **311**: 1401–1405.

Hanley, A. J. G., Harris, S. B., Gittelsohn, J., Wolver, T. M. S., Saksvig, B. and Zinman, B., 2000, Overweight among children and adolescents in native Canadian community: prevalence and associated factors. *American Journal of Clinical Nutrition,* **71**: 693-700.

Hara, M., Saitou, E., Iwata, F., Okada, T. and Harada, K. 2002, Waist-to-height ratio is the best predictor of cardiovascular disease risk factors in Japanese schoolchildren. *Journal of Atherosclerosis and Thrombosis,* **9**: 127-132.

Harder, T., Bergmann, R., Kallischnigg, G. and Plagemann, A., 2005. Duration of breastfeeding and risk of overweight: a meta-analysis. *American Journal of Epidemiology*, **162**: 397-403.

Harris, S. M., 1994, Racial differences in predictors of college women's body image attitudes. *Women Health,* **21**: 89–104.

Hartz, A. J., Rupley, D. C. Jr., Kalkhoff, R. D. and Rimm, A. A., 1983, Relationship of obesity to diabetes: influence of obesity level and body fat distribution. *Preventive Medicine,* **12**: 351–357.

Hauner, H., Rohrig, K. and Petruschke, T., 1995. Effects of epidermal growth factor (EGF), platelet-derived growth factor (PDGF) and fibroblast growth factor (FGF) on human adipocyte development and function. *European Journal of Clinical Investigation,* **25**: 90-6.

Hayden-Wade, H. A., Richard I. S., Ata, G., Brian, E. S., Marion F. Z. and Denise, E. W., 2005. Prevalence, characteristics, and correlates of teasing experiences among overweight children vs. non-overweight peers. *Obesity Research,* **13**: 1381–1392.

Health Canada, 2003, *Canadian Guidelines for Body Weight Classification in Adults.* Ottawa, Canada, pp. 1–40.

Hebebrand, J., Wulftange, H., Goerg, T., et al. 2000, Epidemic obesity: are genetic factors involved via increased rates of assortative mating? *International Journal of Obesity and Related Metabolic Disorders,* **24**: 345–53.

Hediger, M. L., Overpeck, M. D., Kuczmarski, R. J. and Ruan, W. J., 2001. Association between infant breastfeeding and overweight in young children. *Journal of the American Medical Association,* **285**: 2453-2460.

Heinig, M. J., Nommsen, L. A., Peerson, J. M., Lonnerdal, B. and Dewey, K. G., 1993. Energy and protein intakes of breast-fed and formula-fed infants during the first year of life and their association with growth velocity: the Darling study. *American Journal of Clinical Nutrition,* **58**: 152-61.

Heithoff, K. A., Cuffel, J. C., Kennedy, S. and Peters, J., 1997, The association between body mass and health care expenditures. *Clinical Therapeutics,* **19**: 811 – 820.

Henriksson, K. M., Lindblad, U., Agren, B., Nilsson-Ehle, P. and Rastam, L., 2001, Associations between body height, body composition and cholesterol levels in middle-aged men. The coronary risk factor study in southern Sweden. CRISS. *European Journal of Epidemiology*, **17**(6): 521-526.

Hernandez, B., Gortmaker, S. L., Colditz, G. A., Peterson, K. E., Laird, N. M. and Parra-Cabrera, S., 1999. Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico city. *International Journal of Obesity and Related Metabolic Disorders*, **23**: 845–54.

Hesketh, K., Wake, M. and Waters, E., 2004. Body mass index and parent-reported self-esteem in elementary school children: evidence for a causal relationship. *International Journal of Obesity and Related Metabolic Disorders*, **28**: 1233-7.

Heyward, V. H. 1996, Evaluation of body composition - Current issues. *Sports Medicine*, **22**: 146 –56.

Heyward, V. H. and Wagner, D. R., 2004, Body composition and ethnicity in applied body composition assessment. *Human Kinetics,* **6**: 135-172.

Hickman, T. B., Brefel, R. R., Margaret, D. and Johnson, P. S. H. 2002. Distribution and trends of serum lipid levels among children and adolescents ages 4-19 years. Data from the third National Health and Nutrition Examination surveys. P.132.

Higgins, P. B., Gower, B. A., Hunter, G. R. and Goran, M. I. 2001, Defining health-related obesity in pre-pubertal children. *Obesity Research,* **9**: 233–240.

Hill, J. O. and Peters, J. C., 1998, Environmental contributions to the obesity epidemic. *Science*, **280**: 1371–1374.

Hill, J. O. and Trowbridge, F., 1998, Childhood obesity: future directions and research priorities. *Pediatrics*, **101**: 570–574.

Himes, J. H. and Dietz, W. H. 1994, Guidelines for overweight in adolescent preventive services - recommendations from an expert committee. *American Journal of Clinical Nutrition*, **59**: 307-316.

Ho, S. Y., Lam, T. H. and Janus, E. D., 2003, Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. *Annals of Epidemiology*, **13**: 683-691.

Hortobagyi, T., Israel, R. G. and Brien, K. F., 1994, Sensitivity and specificity of the Quetelet index to assess obesity in men and women. *European Journal of Clinical Nutrition*, **48**: 369–375.

Hsieh, S. D. and Yoshinaga, H. 1995a, Abdominal fat distribution and coronary heart disease risk factors in men-waist/height ratio as a simple and useful predictor. *International Journal of Obesity*, **19**: 585-589.

Hsieh, S. D. and Yoshinaga, H. 1995b, Waist/height ratio as a simple and useful predictor of coronary heart disease risk factors in women. *Japanese Society of Internal Medicine*, **34**: 1147-1152.

Hsieh, S. D., Yoshinaga, H. and Muto, T., 2003, Waist-to-height ratio, a simple and practical index for assessing central fat distribution and metabolic risk in Japanese men and women. *International Journal of Obesity Related Metabolic Disorders*, **27**: 610-16.

Hsieh, S. D., Yoshinaga, H., Muto, T., Sakurai, Y. and Kosaka, K., 2000, Health risks among Japanese men with moderate body mass index. *International Journal of Obesity Related Metabolic Disorders*, **24**(3): 358-362.

http://www.ncaer.org/downloads/IPF2008/presentation5.ppt retrieved on 16.6.2009.

Hu, F. B., Li, T. Y., Colditz, G. A. and Willett, W. C., 2003. Television watching and other sedentary behaviours in relation to risk of obesity and Type 2 Diabetes Mellitus in women. Journal of American Medical Association, 289: 1785-91.

Hulman, S., Kushner, H., Katz, S. and Falkner, B., 1998, Can cardiovascular risk be pre-dicted by newborn, childhood, and adolescent body size? An examination of longitudinal data in urban African Americans. *Journal of Pediatrics*, **132**: 90-97.

ICMR, Indian Council of Medical Research, 1990, *Nutrient Requirements and Recommended Dietary Allowances for Indians*, National Institute of Nutrition, Hyderabad, India, pp. 83.

ICMR, Indian Council of Medical Research, 1998, *Dietary Guidelines for Indians – A Manual*, National Institute of Nutrition, Hyderabad, India, p. 65.

ICMR, Indian Council of Medical Research, 2009. Pre conference workshop on "Assessment of Nutritional status and dissemination of new RDA for Indians".19th November, 2009.National Institute of Nutrition, Hyderabad.

India Economic Survey, 2009. Ministry of Finance. Government of India. Available at http://indiabudget.nic.in/es2008-09/esmain.htm

Irving, L. M. and Neumark-Sztainer, D. 2002, Integrating the prevention of eating disorders and obesity: feasible or futile? *Preventive Medicine,* **34**: 299-309.

James, J., Thomas, P., Cavan, D. and Kerr, D. 2004, Preventing childhood obesity by reducing consumption ofcarbonated drinks: cluster randomised controlled trial. *British Medical Journal,* **328**: 1237.

James, W. P. T., Luizzi, F. and Waterlow, J. C. 1988, Definition of chronic energy deficiency in adults – Report of working party of the intervention of Dietary Energy Consultation Group. *American Journal of Clinical Nutrition*, **42**: 968-981.

Janssen, I., Heymsfield, S. B., Allison, D. B., Kotler, D. P. and Ross, R., 2002a, Body mass index and waist circumference independently contribute to the prediction of non abdominal, abdominal subcutaneous, and visceral fat. *American Journal of Clinical Nutrition,* **75**: 683–8.

Janssen, I., Katzmarzyk, P. T. and Ross, R., 2002b, Body mass index, waist circumference, and health risk: evidence in support of current National Institutes of Health guidelines. *Archives of International Medicine,* **162**: 2074–2079.

Janssen, I., Katzmarzyk, P. T., Ross, R., Leon, A. S., Skinner, J. S., Rao, D.C., Wilmore, J. H., Rankinen, T. and Bouchard, C., 2004, Fitness alters the associations of BMI and waist circumference with total and abdominal fat. *Obesity Research*, **12**: 525-537.

Janz, K. F., Levy, S. M., Burns, T. L., Torner, J. C., Willing, M. C. and Warren, J. J., 2002. Fatness, physical activity, and television viewing in children during the adiposity rebound period: the Iowa Bone Development Study. *Preventive Medicine*, **35**: 563–71.

Jason, C. G., Halford, E., Boyland, E. J., Cooper, G. D., Dovey, T. M., Smith, C. J., Williams, N., Lawton, C. L. and Blundell, J. E., 2009. Children's food preferences: Effects of weight status, food type, branding and television food advertisements (commercials). *International Journal of Paediatrics*, **3**: 31-38.

Jeffery, R. W. and French, S. A., 1998. Epidemic obesity in US: Are fast foods and television viewing contributing? *American Journal of Public Health*, **88**: 277-280.

Jelliffe, D. B. 1966. The assessment of the nutritional status of the community. *WHO Monograph Series*, **33**: 50-52.

Jelliffe, D. B. and Jelliffe, D. E. F. 1991, *Community Nutrition Assessment*, Oxford Medical Publication, pp 13-93.

Jeor, S. T., Perumean-Chaney, S., Sigman-Grant, M., Williams, C. and Foreyt, J., 2002, Family based intervention for the treatment of childhood obesity. *Journal of American Dietetic Association*, **102**: 640–644.

Jia, W. P., Xiang, K., Chen, L., Xu, J. and Wu, Y., 2002, Epidemiological study on obesity and its comorbidities in urban Chinese older than 20 years of age in Shanghai, China. *Obesity Reviews*, 3: 157–176.

Kahn, H. S., Imperatore, G. and Cheng, J. Y. 2005, A population based comparison of BMI percentiles and waist to height ratio for identifying cardiovascular risk in youth. *Journal of Pediatrics*, **146**: 482-488.

Kain, J., Uauy, R., Lera, L., Taibo, M. and Albala, C. 2005, Trends in height and BMI of 6-year-old children during the nutrition transition in Chile. *Obesity Research*, **13**: 2178 –2186.

Kamath, S. 1986, *Nutritional Assessment and Health Assessment.* 3rd Ed., The C. V. Mosby Company, St. Louis, Toronto, Princeton, pp. 132.

Kapil, U. 2004, The problem of overweight and obesity. *Proceedings of the National Seminar on Obesity – A well fed undernourished syndrome*, St. Theresa's College, Ernakulam, Kerala, India, pp. 7-18.

Kapil, U., Singh, P., Pathak, P., Dwivedi, S.N. and Bhasin, S., 2002. Prevalence of obesity amongst affluent adolescent school children in Delhi. *Indian Paediatrics*, **39**: 449-452.

Kapur, P. and Sethi, M., 2003, Dietary profile and physical activity pattern of Indian obese versus normal weight children. Proceedings of 35th Annual Conference of Indian Dietetic Association, p. 46.

Katzmarzyk, P. T., Janssen, I. and Ardern, C. I., 2003. Physical inactivity, excess adiposity and premature mortality. *Obesity Reviews*, **4**: 257–90.

Katzmarzyk, P. T., Malina, R. M., Song, T. M. and Bouchard, C., 1998a. Physical activity and health-related fitness in youth: a multivariate analysis. *Medicine and Science in Sports and Exercise*, **30**: 709–14.

Katzmarzyk, P. T., Malina, R. M., Song, T. M. and Bouchard, C., 1998b. Television viewing, physical activity, and health-related fitness of youth in the Quebec Family Study. *Journal of Adolescent Health*, **23**: 318–25.

Kaur, S., Kapil, U. and Singh, P. 2005, Pattern of chronic diseases amongst adolescent obese children in developing countries. *Current Science*, **88**: 1052– 1056.

Keith, S., Redden, D., Katzmarzyk, P., Boggiano, M., Hanlon, E., Benca, R., Ruden, D., Pietrobelli, A., Barger, J. and Fontaine, K. 2006, Putative contributors to the secular increase in obesity: exploring the roads less travelled. *International Journal of Obesity,* **30**: 1585-1594.

Kelley, D. E., Thaete, F. L., Troost, F., Huwe, T. and Goodpaster, B. H., 2000, Subdivisions of subcutaneous abdominal adipose tissue and insulin resistance. *American Journal Physiology Endocrinology Metabolism*, **278**: E941–8.

Kennedy, E. T., Bowman, S A., Spence, J. T., Freedman, M. and King, J., 2001. Popular diets: Correlation to health, nutrition and obesity. Journal of the American Dietetic Association, 101: 411-20.

Kerala Family Health Survey, 2009. Median age at marriage among women in age 25-49. Department of Health, Government of Kerala. Available at http://wwwscribd.com/doc/19494382/Kerala-Family-Health-Survey

Khadilkar, V. V., Khadilkar, A. V., Choudhury, P., Agarwal, K. N., Ugra, D. and Shah, N. K., 2007, IAP growth monitoring guidelines for children from birth to 18 years. *Indian Pediatrics*, **44**: 187-197.

Killen, J. D., Telch, M. J., Robinson, T. N., Maccoby, N., Taylor, C. B. and Farquhar, J. W., 1988, Cardiovascular disease risk reduction for tenth graders: a multiple-factor school-based approach. *The Journal of the American Medical Association*, **260**: 1728–1733.

Kim, Y., Suh, Y. K. and Choi, H., 2004, BMI and metabolic disorders in South Korean Adults: 1998 Korea Health and Nutrition Survey. *Obesity Research,* **3**: 445–53.

Kimm, S. Y., Glynn, N. W., Kriska, A. M., *et al*., 2000. Longitudinal changes in physical activity in a biracial cohort during adolescence. *Medicine and Science in Sports and Exercise,* **32**: 1445–54.

Kimm, S. Y., Obarzanek, E., Barton, B. A., *et al*., 1996. Race, socioeconomic status, and obesity in 9- to 10-year-old girls: the NHLBI Growth and Health Study. *Annals of Epidemiology,* **6**: 266–75.

Klesges, R. C., Shelton, M. L. and Klesges, L. M. 1993, Effects of television on metabolic rate: potential implications for childhood obesity. *Pediatrics,* **91**: 281– 6.

Kolagotla, L. and Adams, W., 2004. Ambulatory management of childhood obesity. *Obesity Research,* **12**: 275–283.

Koletzko, B., Girardet, J. P., Klish, W. and Tabacco, O., 2002, Obesity in children and adolescents worldwide: current views and future directions-Working Group Report of the First World Congress of Pediatric Gastroenterology, Hepatology, and Nutrition. *Journal of Pediatric Gastroenterology and Nutrition,* **35** (Suppl 2): S205–12.

Koletzko, B., von Kries, R., Monasterolo, R. C., Subias, J. E., Scaglioni, S., Giovannini, M., Beyer, J., Demmelmair, H., Anton, B., Gruszfeld, D., Dobrzanska, A., Sengier, A., Langhendries, J.-P., Rolland Cachera, M.-F. and Grote, V., 2009. Can infant feeding choices modulate later obesity risk? *American Journal of Clinical Nutrition,* **89**: 1502S-1508S.

Kothari, C. R. 2001, *Research Methodology*, Wishwa Prakashan, Daryaganj, New Delhi. pp. 74.

Kothari, C. R. 2005, *Research Methodology, Methods and Techniques*, 2nd Ed., New Age Publications, New Delhi. pp. 97.

Kuczmarski, R. J. and Flegal, K. M. 2000, Criteria for definition of overweight in transition: background and recommendations for the United States. *American Journal of Clinical Nutrition*, **72**: 1074-1081.

Kuczmarski, R. J., Flegal, K. M., Campbell, S. M. and Johnson, C. L., 1994, Increasing prevalence of overweight among US adults: the National Health and Nutrition Examination Surveys, 1960 to 1991. *Jornal of the American Medical Association*, **272**: 205–11.

Kuh, D., Hardy, R., Chaturvedi, N. and Wadsworth, M. E., 2002, Birth weight, childhood growth and abdominal obesity in adult life. *International Journal of Obesity and Related Metabolic Disorders*, **26**: 40-7.

Kumanyika, S. K. and Morssink, C. B. 1997, Cultural appropriateness of weight management programs. In: *Overweight and Weight Management,* Dalton, S., (Ed.), Gaithersburg, MD, Aspen Publisher, pp. 69–106.

Kumanyika, S. K., Wilson, J. and Guilford-Davenport, M., 1993, Weight related attitudes and behaviors of black women. *Journal of the American Dietetic Association*, **93**: 416–22.

Kyle, U. G., Piccoli, A. and Pichard, C., 2003, Body composition measurements – Interpretations finally made easy for clinical use. *Current Opinion in Clinical Nutrition and Metabolic Care*, **6**: 387-393.

Lagiou, A. and Parava, M., 2008. Correlates of childhood obesity in Athens, Greece. *Public Health Nutrition,* **11**: 940-945.

Lamerz, A., Kuepper-Nybelen, J., Wehle, C., Bruning, N., Trost-Brinkhues, G., Brenner, H., Hebebrand, J. and Herpertz-Dahlmann, B., 2005. Social class, parental education, and obesity prevalence in a study of six-year-old children in Germany. *International Journal of Obesity*, **29**: 373-380.

Landrine, H. and Klonoff, E., 1994, The African American Acculturation Scale: development, reliability and validity. *J Black Psychology,* **20**: 104–27.

Lapidus, L., Bengtsson, C., Larsson, B., Pennert, K., Rybo, E. and Sjstrom, L., 1984, Distribution of adipose tissue and risk of cardiovascular disease and death: a 12-year follow up of participants in the population study of women in Gothenburg, Sweden. *British Medical Journal,* **289**: 1257–1261.

Larsson, B., Svardsudd, K., Welin, L., Wilhelmsen, L., Bjorntorp, P. and Tibblin, G., 1984, Abdominal adipose tissue distribution,obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. *British Medical Journal,* **288**: 1401–1404.

Latner, J. D. and Stunkard, A. J. 2003, Getting worse: the stigmatization of obese children. *Obesity Research,* **11**: 452– 6.

Latner, J. D., Murray, S., Juliet, K. R. and Stunkard, A. J. 2007, Assessment of obesity stigmatization in children and adolescents: modernizing a standard measure. *Obesity,* **15**: 3078 –3085.

Lauer, R. M. and Clarke, W. R., 1989. Childhood risk factors for high adult blood pressure: the Muscatine Study. *Pediatrics,* **84**: 633–41.

Laxmaiah, A., Nagalla, B., Vijayaraghavan, K. and Nair, M., 2007, Factors affecting prevalence of overweight among 12 to 17 year-old urban adolescents in Hyderabad, India. *Obesity*, **15**: 1384 –1390.

Lazarus, R., Wake,M., Hesketh, K. and Waters, E., 2000, Change in body mass index in Australian primary school children.1985–1997. *International Journal of Obesity Related Metabolic Disorders*, **24**: 679-684.

Lean, M. E., Han, T. S. and Morrison, C. E., 1995, Waist circumference as a measure for indicating need for weight management. *British Medical Journal,* **311**: 158–64.

Lederman, S. A., Akabas, S. R. and Moore, B. J., 2004, Summary of the presentations at the Conference on Preventing Childhood Obesity, December 8, 2003. *Pediatrics*, **114**: 1146 –73.

Ledoux, M., Lampert, J., Reeder, B. A. and Despre´s, J. P., 1997a, Correlation between cardiovascular disease risk factors and simple anthropometric measures. *Canadian Medical Association Journal,* **157**: S46–S53.

Ledoux, M., Lampert, J., Reeder, B. A. and Despre’s, J. P., 1997b, A comparative analysis of weight to height and waist to hip circumference indices as indicators of the presence of cardiovascular disease risk factors. *Canadian Medical Association Journal,* **157**: S32–S8.

Lee, J. S., Aoki, K., Kawakubo, K. and Gunji, A., 1995, A study on indices of body fat distribution for screening for obesity. Journal of Occupational Health, **37**: 9-18.

Lee, K., Sohn, H., Lee, S. and Lee, J., 2004, Weight and BMI over 6 years in Korean children: relationships to body image and weight loss efforts. *Obesity Research*, **12**: 1959–1966.

Lee, Z., Critchley, J. and Ko, G., 2002, Obesity and cardiovascular risk factors in Hong Kong Chinese. *Obesity Reviews*, **3**: 173–182.

Lehingue, Y., 1999, The European Childhood Obesity Group (ECOG) project: the European collaborative study on the prevalence of obesity in children. *American Journal of Clinical Nutrition*, 70:166-168.

Lemieux, I., Pascot, A., Couillard, C., Lamarche, B., Tchernof, A., Almeras, N., Bergeron, J., Gaudet, D., Tremblay, G., Prud'homme, D., Nadeau, A. and Despres, J. P., 2000. Hypertriglyceridemic waist: a marker of the atherogenic metabolic triad (hyperinsulinaemia; hyperapolipoprotein B; small dense LDL) in men? *Circulation*, **102**: 179-184.

Lemieux, S., Prud'homme, D., Bouchard, C., Tremblay, A. and Despres, J. P., 1996, A single threshold value of waist girth identifies normal-weight and overweight subjects with excess visceral adipose tissue. *American Journal of Clinical Nutrition*, **64**: 685–693.

Lenthe, F. J., Kemper, C. G. and van Mechelen, W., 1996, Rapid maturation in adolescence results in greater obesity in adulthood: the Amsterdam growth and health study. *American Journal of Clinical Nutrition,* **64**: 18-24.

Li, L., Parsons, T. J. and Power, C., 2003. Breast feeding and obesity in childhood: cross sectional study. *British Medical Journal*, **327**: 904-5.

Li, R., Fein, S. B. and Grummer-Strawn, L. M., 2008. Association of breastfeeding intensity and bottle-emptying behaviors at early infancy with infants' risk for excess weight at late infancy. *Pediatrics*, **122**: S77-S84.

Lin, W. Y., Lee, L. T., Chen, C. Y., Lo, H., Hsia, H. H., Liu, I. L., Lin, R. S., Shau, W. Y. and Huang, K. C. 2002, Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan. *International Journal of Obesity and Related Metabolic Disorders*, **26**: 1232-1238.

Lionis, C., Kafatos, A., Vlachonikolis, J., Vakaki, M., Tzortzi, M. and Petraki, A., 1991, The effects of a health education intervention program among Cretan adolescents. *Preventive Medicine,* **20**: 685–699.

Liu, S. and Manson, J. E., 2001, What is the optimal weight for cardiovascular health? *British Medical Journal,* **322**: 631–632.

Livingstone, M. B., 2001, Childhood obesity in Europe: a growing concern. *Public Health Nutrition,* **4**: 109 –16.

Lobstein, T., Baur, L. A. and Uauy, R. 2004, Obesity in children and young people: a crisis in public health. *Obesity Reviews*, **5** (Suppl 1): 4-85.

Locard, E., Mamelle, N., Billette, A., Miginiac, M., Munoz, F. and Rey, S., 1992, Risk factors of obesity in a five year old population. Parental versus environmental factors. *International Journal of Obesity Related Metabolic Disorders,* **16**: 721–729.

Lohman, T. G. 1981. Skinfolds and body density and their relation to body fatness: a review. *Human Biology,* **53**: 181–225.

Lucas, A., Boyes, S., Bloom, S. R. and Aynsley-Green, A., 1981. Metabolic and endocrine responses to a milk feed in six-day-old term infants: differences between breast and cow's milk formula feeding. *Acta Paediatrica Scandinavica*, **70**: 195-200.

Lucas, A., Sarson, D. L., Blackburn, A. M., Adrian, T. E., Green, A, Bloom,S.R.. 1980. Breast vs bottle: endocrine responses are different with formula feeding. *Lancet*; 1:1267-9.

Ludwig, D. S., Peterson, K. E. and Gortmaker, S. L. 2001, Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet*, **357**: 505-508.

Lyu, L. C., Hsu, C. Y., Yeh, C. Y., Lee, M. S., Huang, S. H. and Chen, C. L. 2003, A case-control study of the association of diet and obesity with gout in Taiwan. *American Journal of Clinical Nutrition*, **78**: 690-701.

Maes, H. H., Neale, M. C. and Eaves, L. J. 1997, Genetic and environmental factors in relative body weight and human adiposity. *Behaviour Genetics*, **27**: 325–351.

Maffeis, C., Pietrobelli, A., Grezzani, A., Provera, S. and Taté, L., 2001. Waist circumference and cardiovascular risk factors in prepubertal children. *Obesity Research*, **9**: 179-87.

Maffeis, C., Talamini, G. and Tato, L., 1998. Influence of diet, physical activity and parents' obesity on children's adiposity: a fouryear longitudinal study. *International Journal of Obesity Related Metabolic Disorders*, **22**: 758–64.

Malecka-Tendera, E., Klimek, K., Matusik, P., Olszanecka-Glinianowicz, M. and Lehingue, Y., 2005. Obesity and overweight prevalence in Polish 7- to 9-year-old children. *Obesity Research*, **13**: 964 –968.

Malina, R. M. and Katzmarzyk, P. T., 2006. Physical activity and fitness in an international growth standard for preadolescent and adolescent children. Food and Nutrition Bulletin, 27: S295-313.

Malina, R. M., 2001. Physical activity and fitness: pathways from childhood to adulthood. *American Journal of Human Biology*, **13**: 162–72.

Manson, J. E., Willett, W. C. and Stampfer, M. J., 1995, Body weight and mortality among women. *New England Journal of Medicine,* **333**: 677–685.

Matthews, D. R., Hosker, J. P., Rudenski, A. S., Naylor, B. A., Treacher, D. F. and Turner, R. C., 1985. Homeostasis model assessment:insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia*, 28: 412–9.

Maya, C., 2007, A weighty problem in the making. *The Hindu*, Thiruvananthapuram Edition, Dated 19.02.2007.

Mc. Swan, L., Junjuna, C. and Puetpaiboon, 1993, A.Increasing obesity in school children in a transitional society and the effect of the weight control programme. *South East Asian Journal of Tropical Medicine and Public Health*, **24**: 590-594.

Mc.Nutt, S. W., Hu, Y., Schreiber, G. B., Crawford, P. B., Obarzanek, E. and Mellin, L., 1997, A longitudinal study of the dietary practices of black and white girls 9 and 10 years old at enrollment: the NHLBI Growth and Health Study. *Journal of Adolescent Health,* **20**: 27–37.

McCallum, Z. and Gerner, B. 2005. Weighty matters-an approach to childhood overweight in general practice. *Australian Family Physician,* **34**:745-748.

McCarthy, H. D. and Ashwell, M., 2002, Waist:Height ratios in British children aged 5-16 years: a suggestion for a simple public health message-keep your waist circumference to less than half your height. *Proceedings of Nutrition Society,* **61**: 116A.

McCarthy, H. D. and Ashwell, M., 2003, Trends in waist-height ratios in British children aged 11-16 over a two decade period. *Proceedings of Nutrition Society*, **62**: 46A.

McCarthy, H. D., Cole, T. J., Fry, T., Jebb, S. A. and Prentice, A. M., 2006, Body fat reference curves for children. *International Journal of Obesity,* **30**: 598–602.

McCarthy, H. D., Jarrett, K. V. and Crawley, H. F. 2001, The development of waist circumference percentiles in British children aged 5.0 – 16.9 y. *European Journal of Clinical Nutrition,* **55**: 902-907.

McElroy, S. L., Kotwal, R., Malhotra, S., Nelson, E. B., Keck, P. E. and Nemeroff, C. B. 2004, Are mood disorders and obesity related? A review for the mental health professional. *Journal of Clinical Psychiatry,* **65**: 634-651.

Megan, A., McCrory, A. and Fuss, P. J., 1999. Dietary variety within food groups: association with energy intake and body fatness in men and women. *American Journal of Clinical Nutrition,* **69**: 440- 447.

Mei, Z., Grummer-Strawn, L. M., Pietrobelli, A., Goulding, A., Goran, M. I. and Dietz, W. H., 2002. Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. *American Journal of Clinical Nutrition,* **75**: 978–985.

Merchant, A. T., Dehghan, M., Cook, D. B. and Anand, S. S. 2007, Diet, physical activity and adiposity in children in poor and rich neighborhoods: a cross sectional comparison. *Nutrition Journal*, **6**: 1.

Michielutte, R., Diseker, R. A., Corbett, W. T., Schey, H. M. and Ureda, J. R., 1984, The relationship between weight-height indices and the triceps skinfold measure among children age 5 to 12. *American Journal of Public Health*, **74**: 604–606.

Ming, L., Dibley, M. J., Sibbritt, D. and Yan, H., 2009. An assessment of adolescent overweight and obesity in Xi'an City China. *International Journal of Pediatric Obesity*. **1**: 50-58.

Misra, A. and Khurana, L., 2008, Obesity and the metabolic syndrome in developing countries. The Journal of clinical endocrinology and metabolism, **93** Supplement: S9 - S30

Misra, A., Chowbey, P., Makkar, B. M., Vikram, N. K., Wasir, J. S., et al., 2009, Consensus statement for diagnosis of obesity, abdominal obesity and metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. Journal of Association of Physicians of India. 57: 163-170.

Misra, A., Garg, A., Abate, N., Peshock, R. M., Stray-Gundersen, J. and Grundy, S. M., 1997, Relationship of anterior and posterior subcutaneous abdominal fat to insulin sensitivity in nondiabetic men. *Obesity Research*, **5**: 93–99.

Monga, S. and Khanna, K., 2003, Obesity among school children (7-9 years) in Delhi-Prevalence and related factors. *Proceedings of IX Asian Congress of Nutrition*, p.322.

Monsivais, P. and Drewnowski, A., 2007. The rising cost of low-energy density foods. *Journal of American Dietetic Association,* **107**: 2071–2076.

Monteiro, C. A., Conde, W. L. and Popkin, B. M., 2001. Independent effects of income and education on the risk of obesity in the Brazilian adult population. *Journal of Nutrition*, **131**: 881S-886S.

Monteiro, C. A., Conde, W. L. and Popkin, B. M., 2004. The burden of disease from undernutrition and overnutrition in countries undergoing rapid nutrition transition: a view from Brazil. *American Journal of Public Health,* **94**: 433–434.

Monteiro, C. A., Montini, L., de Souza, A. L. and Popkin, B. M., 1995. The nutrition transition in Brazil. *European Journal of Clinical Nutrition*, **49**: 105-113.

Monteiro, P. O. A., Victora, C. G., Barros, F. C. and Monteiro, L. M. A., 2003, Birth size, early childhood growth, and adolescent obesity in a Brazilian birth cohort. *International Journal of Obesity,* **27**: 1274–1282.

Moreno, L. A., Fleta, J., Mur, L., Feja, C., Sarria, A. and Bueno, M., 1997, Indices of body fat distribution in Spanish children aged 4.0 to 14.9 years. *Journal of Pediatric Gastroenterology and Nutrition,* **25**: 175-181.

Moreno, L. A., Fleta, J., Mur, L., Rodriguez, G., Sarria, A. and Bueno, M., 1999, Waist circumference values in Spanish children-gender-related differences. *European Journal of Clinical Nutrition*, **53**: 429-433.

Moreno, L. A., Sarria, A., Fleta, J., Rodriguez, G. and Beuno, M., 2000, Trends in body mass index and overweight prevalence among children and adolescents in the region of Aragon (Spain) from 1985 to 1995. *International Journal of Obesity Related Metabolic Disorders,* **24**: 925–931.

Morrison, J. A., Sprecker, D. L, Barton, B. A., Waclawiw, M. A. and Daniels, S. R., 1999, Overweight, fat patterning, and cardiovascular disease risk factors in black and white girls: the NHLBI Study. *Journal of Pediatrics,* **135**: 458–64.

Mudur, G., 2003. Asia grapples with obesity epidemics, World Health Organization. Obesity: preventing and managing the global epidemic. Geneva. *British Medical Journal,* **326**: 515.

Murata, M., 2000, Secular trends in growth and changes in eating patterns of Japanese children. *American Journal of Clinical Nutrition,* **72**: 1379S–1383S.

Murray, J. P. and Kippax, S., 1977. Television diffusion and social behaviour in three communities: a field experiment. *Australian Journal of Psychology,* **29**: 31–43.

Must, A., Dallal, G. E. and Dietz, W. H., 1991, Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht^2) and triceps skinfold thickness. *American Journal of Clinical Nutrition,* **53**: 839–46.

Must, A., Spadano, J., Coakley, E. H., Field, A. E., Colditz, G. and Dietz, W. H., 1999, The disease burden associated with overweight and obesity. *The Journal of the American Medical Association,* **282**: 1523–1529.

Mykkanen, L., Laasko, M. and Pyörälä, K. 1992, Association of obesity and distribution of obesity with glucose tolerance and cardiovascular risk factors in the elderly. *International Journal of Obesity and Related Metabolic Disorders,* **16**: 695–704.

Naik, R. S. and Begum, J. M., 2004, Nutritional status of preschool children of rural rainfed agricultural families. *Proceedings of the Nutrition Society of India*, XXXVI Annual Meet, 5-6th November. pp. 88.

National High Blood Pressure Education Programme Working Group on High Blood Pressure in Children and Adolescents. 2004. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics.* **114**: 555-76.

Navarro, D., Blanca, E., Zquez-Monroy, O. V., Claudia, P., Nchezcastillo, S. A., Lara-Esqueda, A.´N., Arturoberber, G. F., 2004. The high prevalence of overweight and obesity in Mexican children. *Obesity Research,* **12**: 215–223.

NCAER, National Council for Applied and Economic Research, 2001, *National Human Development Report -2001.* Oxford, UK, Oxford University Press.

NCEP, National Cholesterol Education Programme, 1988, Expert panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults, *Archives of Internal Medicine*, **148**: 36–39.

NCEP, National Cholesterol Education Programme, 2002. Expert panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults. *Circulation*, **106**: 3143–3421.

Nelson, M. C., Gordon-Larsen, P., North, K. E. and Adair, L. S., 2006. Body mass index gain, fast food, and physical activity: effects of shared environments over time. *Obesity.* **14**: 701–709.

Neumark-Sztainer, D., Falkner, N., Story, M., Perry, C., Hannan, P. J. and Mulert, S. 2002. Weight-teasing among adolescents: correlations with weight status and disordered eating behaviors. *International Journal of Obesity and Related Metabolic Disorders,* **26**: 123–31.

Neumark-Sztainer, D., Story, M. and Harris, T. 1999. Beliefs and attitudes about obesity among teachers and school health care providers working with adolescents. *Journal of Nutrition Education,* **31**: 3–9.

Neutzling, M. B., Hallal, P. R. C., Araujo, C. L. P., Horta, B. L., Viera, M. F. A., Menezes, A. M. B. and Victora, C. G., 2009. Infant feeding and obesity at 11 years: Prospective birth cohort study. *International Journal of Obesity*, **4**: 143-149.

NIH, National Institutes of Health, 1998. National Heart, Lung and Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: the evidence report. *Obesity Research,* **6**: S51–210.

NIH, National Institutes of Health, 2000. *The Practical Guide: Identification, Evaluation and Treatment of Overweight and Obesity in Adults.* Bethesda, MD, pp. 1–77.

NIN, National Institute of Nutrition, 1983, *A Manual of Laboratory Techniques,* (Eds.), Raghuramalu, N., Nair, K. M. and Kalyansundaram, S., Hyderabad, India, pp. 180–184.

NIN, National Institute of Nutrition, 2005, *Dietary Guidelines for Indians – A Manual*, Hyderabad, India, p.30.

NNMB, 1984. Average intake of food stuffs in urban low income groups. Report on urban population, ICMR, New Delhi, p.28.

O’Brien, K. S., Hunter, J. A. and Banks, M. 2007. Implicit anti-fat bias in physical educators: physical attributes, ideology, and socialization. *International Journal of Obesity,* **31**: 308 –14.

O'Brien, S. H., Holubkov, R. and Reis, E.C. 2004, Identification, evaluation, and management of obesity in an academic primary care centre. *Pediatrics* 114**:**154-159.

Ogden, C. L., Flegal, K. M., Carroll, M. D. and Johnson, C. L., 2002. Prevalence and trends in overweight among US children and adolescents 1999–2000. *The Journal of the American Medical Association,* **288**: 1728–1732.

Ogden, C. L., Troiano, R. P., Briefel, R. R., Kuczmarski, R. J., Flegal, K. M. and Johnson, C. L., 1997. Prevalence of overweight among preschool children in the United States, 1971-1994. *Pediatrics,* **99**: E1–7.

Ogden, J. and Chanana, A., 1998. Explaining the effect of ethnic group on weight concern: finding a role for family values. *International Journal of Obesity Related Metabolic Disorders,* **22**: 641–647.

Olds, E. G., 1938, Distribution of sums squares of rank differences for small numbers of individuals. *Annals of Mathematics and Statistics*, **9**: 133-148.

Olivares, S., Kain, J., Lera, L., Pizarro, F., Vio, F. and Moron, C., 2004, Nutritional status, food consumption and physical activity among Chilean school children: a descriptive study. *European Journal of Clinical Nutrition,* **58**: 1278–85.

Onat, A., 1999, Waist circumference and waist-to-hip in Turkish adults: interrelation with other risk factors and association with cardiovascular disease. *International Journal of Cardiology*, **70**: 43–50.

Ong, K. K., Ahmed, M. L., Emmett, P. M., Preece, M. A. and Dunger, D. B. 2000, Association between postnatal catch-up growth and obesity in childhood: prospective cohort study. *British Medical Journal*, **320**: 967–71.

Owen, C. G, Martin, R. M, Whincup, P. H, Davey-Smith, G., Gillman, M. W. and Cook, D. G., 2005a. The effect of breastfeeding on mean body mass index throughout life: a quantitative review of published and unpublished observational evidence. *American Journal of Clinical Nutrition*, **82**: 1298-1307.

Owen, C. G., Martin, R. M., Whincup, P. H., Smith, G. D. and Cook, D. G., 2005b. Effect of infant feeding on the risk of obesity across the life course: A quantitative review of published evidence. *Pediatrics*, **115**: 1367-1377.

Padikkal, P. M., 2000. Dietary profile and nutritional profile of school children participating in school lunch programme. M. Sc. (Home Science) Thesis, Kerala Agricultural University, Thrissur, India, pp.68.

Palasciano, G., Portincasa, P. and Vinciguerra, V., 1989. Gallstone prevalence and gallbladder volume in children and adolescents: an epidemiological ultrasonographic survey and relationship to body mass index. *American Journal of Gastroenterology*, **84**: 1378–82.

Panjikkaran, S. T. and Kumari, K. S. 2009. Augmenting BMI and waist height ratio for establishing more efficient obesity percentiles among school going children. *Indian Journal of Community Medicine*, **34**: 135 – 139.

Panjikkaran, S. T. and Usha,V. 2010. A path analysis on the nourishment directed haemoglobin status and resulting endurance capacity of adolescent rural girls. *Journal of Dairying, Foods and Home Science*, **29:** 47-51.

Panjikkaran, S. T., 2001. Nutritional profile and endurance capacity of adolescent girls. M. Sc. (Home Science) Thesis, Kerala Agricultural University, Thrissur, India, pp. 30-91.

Panse, V. G. and Sukhatme, P. V. 1978, *Statistical Methods for Agricultural Workers*, Indian Council of Agricultural Research, New Delhi.

Papadimitriou, A., Dionysia, K., Konstantinidou, P., Xepapadaki, and Nicolaidou P. 2006, Prevalence of obesity in elementary schoolchildren living in Northeast Attica, Greece. *Obesity,* **14**: 1113–1117.

Parcel, G. S., Simons-Morton, B. G., O'Hara, N. M. and Baranowski, T., 1988. School-based programmes to prevent or reduce obesity. In: Ed. Krasnegor, N. A., *Childhood Obesity: A Bio-behavioral Perspective*. Caldwell, NJ, Telford, pp. 143-7.

Park, Y. W., Allison, D., Heymsfield, S. and Gallagher, D., 2001, Larger amounts of visceral adipose tissue in Asian-Americans. *Obesity Research,* **9**: 381–387.

Parsons, T. J., Power, C. and Manor, O., 2001, Fetal and early life growth and body mass index from birth to early adulthood in 1958 British cohort: longitudinal study. *British Medical Journal,* **323**: 1331-1335.

Parsons, T. J., Power, C. and Manor, O., 2003. Infant feeding and obesity through the lifecourse. *Archives of Diseases in Children,* **88**: 793-794.

Parsons, T. J., Power, C., Logan, S. and Summerbell, C. D. 1999, Childhood predictors of adult obesity: a systematic review. *International Journal of Obesity and Related Metabolic Disorders,* **23** (suppl 8): S1-107.

Patel, S., Unwin, N., Bhopal, R., White, M., Harland, J., Ayis, S. A., Watson, W. and Alberti, K. G., 1999, A comparison of proxy measures of abdominal obesity in Chinese, European and South Asian adults. *Diabetic Medicine,* **16**: 853-860.

Patrick, K., Calfas, G. J., Zabinski, M. F. And Cella, J. 2004, Diet, physical activity, and sedentary behaviours as risk factors for overweight in adolescence. *Archives of Pediatrics and Adolescent Medicine,* **158**: 385–90.

Patterson, R. E. and Pietinen, P. 2004, Assessment of nutritional status in individuals and populations. In: *Public Health Nutrition*, Gibney, M. J., Margetts, B. M., Kearny, J. M. and Arab, L. (Eds.), Blackwell Science, Gray Publishings, Gopsons Papers Ltd., Noida, India, pp. 66 – 81.

Paul, A. K., 2004. Obesity in childhood. *Proceedings of the UGC Sponsored National Seminar on Obesity – A Wellfed Undernourished Syndrome,* July 28–30th, 2004 at St. Teresas College, Ernakulam. pp. 21-22.

Paul, M. E., 1993. Food preferences and dietary habits of adolescent among Agricultural Labourers. M. Sc. (Home Science) Thesis, Kerala Agricultural University, Thrissur, India, pp.155.

Paul, S., 2001. Food habits and nutritional profile of adolescents. M. Sc. (Home Science) Thesis, Kerala Agricultural University, Thrissur, India, pp. 125.

Pecoraro, P., Guida, B., Caroli, M., et al., 2003, Body mass index and skinfold thickness versus bioimpedance analysis fat mass prediction in children. *Acta Diabetal*, **40**: 278-81.

Peixoto, L. M. 2002, Adolescent boys and the muscular male body ideal. *Journal of Adolescent Health*, **30**: 233-242.

Perusse, L., Rankinen, T., Rauramaa, R., Rivera, M. A., Wolfarth, B. and Bouchard, C. 2003, The human gene map for performance and health-related fitness phenotypes. *Medicine and Science in Sports and Exercise*, **35**: 1248–64.

Petruschke, T., Rohrig, K. and Hauner, H., 1994. Transforming growth factor beta (TGF-beta) inhibits the differentiation of human adipocyte precursor cells in primary culture. *International Journal of Obesity and Related Metabolic Disorders*, **18**: 532-6.

Phillips, D. I. W. and Young, J. B., 2000, Birth weight, climate at birth and the risk of obesity in adult life. *International Journal of Obesity*, **24**: 281-287.

Phinney, J. S., 1990, Ethnic identity in adolescents and adults: review of research. *Psychology Bulletin*, **198**: 499–514.

Pickett, K. E., Kelly, S., Brunner, E., Lobstein, T. and Wilkinson, R., 2005. Wider income gaps, wider waist bands? An ecological study of obesity and income inequality. *Journal of Epidemiology and Community Health*, **59**: 670-674.

Pine, K. J. 2001, Children's perceptions of body shape: a thinness bias in pre-adolescent girls and associations with femininity. *Clinical Child Psychology and Psychiatry*, **6**: 519-536.

Pinhas-Hamiel, O., Dolan, L. M., Daniels, S. R., Standiford, D., Khoury, P. R. and Zeitler, P., 1996, Increased incidence of non-insulin dependent diabetes mellitus among adolescents. *Journal of Pediatrics,* **128**: 608–615.

Pi-Sunyer, F. X., 1991, Health implications of obesity. *American Journal of Clinical Nutrition,* **53**: 1595S–1603S.

Pi-Sunyer, F. X., 1993, Medical harzards of obesity. *Annals of Internal Medicine*, **119**: 655–660.

Planning Commission, 2008a, Food Security and Public Distribution, In: *Kerala Development Report*, Government of India, Academic Foundation, New Delhi, p.319.

Planning Commission, 2008b, Trends in food expenditure, In: *Kerala Development Report*, Government of India, Academic Foundation, New Delhi, p.328.

Poothullil, J. M., Poulton, R., Williams, S., Hediger, M. L., Ruan, W. J., Overpeck, M. D., Kuczmarski, R. J., Gillman, M. W. and Colditz, G. A., 2001. Breastfeeding and risk of overweight. *Journal of the American Medical Association*, **286**: 1448-1450.

Popkin, B. M. 2001, The nutrition transition and obesity in the developing world. *Journal of Nutrition,* **131** (Suppl): 871–3.

Popkin, B. M. and Doak, C. M. 1998, The obesity epidemic is a worldwide phenomenon. *Nutritional Reviews,* **56**: 106 –14.

Popkin, B. M., 1994. The nutrition transition in low-income countries: An emerging crisis. *Nutrition Reviews,* **52**: 285-298.

Poskitt, E. M. E., 2009. Countries in transition: underweight to obesity non-stop? *Annals of Tropical Paediatrics,* **29**: 1-11.

Potter, B. K., Pederson, L. L., Chan, S. S. H., Aubut, J. A. and Koval, J. J. 2004, Does a relationship exist between body weight, concerns about weight, and smoking among adolescents? An integration of the literature with an emphasis on gender. *Nicotine & Tobacco Research,* **6**: 397-425.

Pouliot, M. C., Despre´s, J. P., Lemieux, S., *et al.* 1994. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. *American Journal of Cardiology,* **73**: 460–8.

Power, C., Lake, J. K. and Cole, T. J. 1997, Measurement and long term health risks of child and adolescent fatness. *International Journal of Obesity and Related Metabolic Disorders*, **21**: 507-26.

Power, C., Manor, O. and Matthews, S., 2003. Child to adult socioeconomic conditions and obesity in a national cohort. *International Journal of Obesity Related Metabolic Disorders*, **27**: 1081-6.

Pratanaphon, S., Chamnongkich, S., Hensangvilai, K., 2007, The development of prediction equations for BMI and fat mass from simple anthropometry in 6-to-8-year-old children. *Chiang Mai Medical Journal,* **46**: 31-38.

Prentice, A. and Jebb, S. A. 1995, Obesity in Britain: gluttony or sloth? *British Medical Journal,* **311**: 437-439.

Procter, S. B. and Holcomb, C. A., 2008. Breastfeeding duration and childhood overweight among low-income children in Kansas, 1998-2002. *American Journal of Public Health,* **98**: 106-110.

Proctor, M. H., Moore, L. L., Gao, D., Copples, L. A., Bradlee, M. L., Hood, M. Y. and Ellison, R. C. 2003. Television viewing and change in body fat from preschool to early adolescence: the Framingham Children's Study. *International Journal of Obesity,* **27**: 827-833.

Puhl, R. and Latner, J. 2007, Stigma, obesity, and the health of the nation's children. *Psychological Bulletin,* **133**: 557-580.

Putnam, J. J. and Allshouse, J. E. 1999, Food consumption, prices, and expenditures, 1970-97. Food and Consumers Economics Division, Economic Research Service, US Department of Agriculture, Washington D.C.

Puyau, M. R., Adolph, A. L., Firoz, A. V. and Butte, N. F., 2002. Validation and calibration of activity monitors in children. *Obesity Research,* **10**: 150-7.

Quesenberry, C. P., Caan, B. and Jacobson, A., 1998, Obesity, health services use, and health care costs among members of a health maintenance organization. *Archives of Internal Medicine,* **158**: 466–72.

Raj, M., 2004, Obesity result of flawed diet pattern: study. Significant minority among school children found to be overweight. *The Hindu,* Cochin, dated 07. 01. 2004, p. 13.

Raj, M., Sundaram, K. R., Paul, M., Deepa, A. S. and Krishnakumar, R., 2007, Obesity in Indian children: Time, trends and relationship with hypertension. *The National Medical Journal of India,* **20**: 288-293.

Ramachandran, T. Y. 2004, Prevalence of overweight and obesity among school and college going adolescents in rural and urban Thiruvananthapuram district, Kerala State, India. Working paper No. 7, Achutha Menon Centre for Health

Science Studies, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, pp. 38, available at http://www.sctimst.ac.in/amchss/publications/wp/wp_7.pdf

Rao, D. H. and Vijayaraghavan, K. 1996, Anthropometric assessment of nutritional status. In: *Text Book of Human Nutrition.* Bamji, M. S., Rao, N. P. and Reddy, V. (Eds.), Oxford and IBH Publishing Co. Pvt. Ltd., Calcutta, pp.20-25.

Rasmussen, F. and Johansson, M., 1998, The relation of weight, length and ponderal index at birth to body mass index and overweight among 18-year-old males in Sweden. *European Journal of Epidemiology,* **14**: 373– 380.

Ravelli, G. P. and Belmont, L., 1979. Obesity in nineteen-year-old men: family size and birth order associations. *American Journal of Epidemiology*, **109**: 66-70.

Redline, S., Tishler, P. V., Scluchter, M., Aylor, J., Clark, K. and Graham, G., 1999, Risk factors for sleep-disordered breathing in children. Associations with obesity, race and respiratory problems. *American Journal of Respiratory and Critical Care Medicine*, **159**: 1527–1532.

Reeder, B. A., Senthilselvan, A. and Despre´s, J. P., 1997, The association of cardiovascular disease risk factors with abdominal obesity in Canada. *Canadian Medical Association Journal,* **157**: S39–S45.

Reilly, J. J. 2005. Descriptive epidemiology and health consequences of childhood obesity. *Best Practice & Research Clinical Endocrinology& Metabolism,* **19:** 327-341.

Reilly, J. J. and John, J., 2002, Assessment of childhood obesity: national reference data or international approach? *Obesity Research,* **10**: 838–840.

Reilly, J. J. and McDowell, Z. C., 2003a. Physical activity interventions in the prevention and treatment of paediatric obesity: systematic review and critical appraisal. *Proceedings of the Nutrition Society*, **62**: 611-9.

Reilly, J. J., Methven, E., McDowell, Z. C., Hacking, B., Alexander, D., Stewart, L. and Kelnar, C. J., 2003b, Health consequences of obesity. *Archives of Disease in Childhood,* **88**: 748-752.

Reilly, J. J. Dorosty, A. R. and Emmet, P. 2000, Identification of the obese child: adequacy of the body mass index for clinical practice and epidemiology. *International Journal of Obesity and Related Metabolic Disorders,* **24**: 1623-1627.

Reilly, J. J., Armstrong, J., Dorosty, A. R., Emmett, P. M., Ness, A., Rogers, N. I., Steer, A. S. and Sherriff, A., 2005, Early life risk factors for obesity in childhood: cohort study. *British Medical Journal,* **330**: 1357-63.

Reilly, J. J., Dorosty, A. R. and Emmett, P. M., 1999, Prevalence of overweight and obesity in British children: cohort study. *British Medical Journal,* **319**: 1039.

Reilly, J. J., Jackson, D. M., Montgomery, C., Kelly, L. A., Slater, C., Grant, S. and Paton, J. Y., 2004. Total energy expenditure and physical activity in young Scottish children: mixed longitudinal study. *Lancet,* **363**: 211-2.

Reilly, J. J., Kelly, L., Montgomery, C., Williamson, A., Fisher, A., McColl, J. H., Conte, R. L., Paton, J. Y. and Grant, S., 2006. Physical activity to prevent obesity in young children: cluster randomised controlled trial. *British Medical Journal,* **333**: 1041-45.

Reilly, J. J., Wilson, J. and Durnim, J. V. G. A., 1995. Determination of body composition from skinfold thickness: a validation study. *Archives of Disease in Childhood*, **73**: 305-310.

Reilly, J. J., Wilson, M. L., Summerbell, C. D. and Wilson, A. C., 2002, Obesity: diagnosis, prevention, and treatment; evidence based answers to common questions. *Archives of Disease in Childhood*, **86**: 392-394.

Reilly, J., Ness, A. and Sherriff, A. 2007, Epidemiological and physiological approaches to understanding the etiology of pediatric obesity: finding the needle in the haystack. *Pediatric Research*, **61**: 646-652.

Remacle, C., Bieswal, F. and Reusens, B., 2004. Programming of obesity and cardiovascular diseases. *International Journal of Obesity*, **28**: S46-S53.

Reniscow, K., 1993. School-based obesity prevention. *Annals of New York Academy of Sciences*, 699: 154-6.

Rennie, K., Johnson, L. and Jebb, S. A. 2005, Behavioural determinants of obesity. *Best Practice & Research Clinical Endocrinology & Metabolism*, **19**: 343-358.

Rexrode, K. M., Carey, V. J. and Hennekens, C. H., 1998, Abdominal adiposity and coronary heart disease in women. *The Journal of the American Medical Association*, **280**: 1843–1848.

Ricciardelli, L. A. and McCabe, M. P. 2001, Children's body image concerns and eating disturbance: A review of the literature. *Clinical Psychology Review*, **21**: 325-344.

Richmond, W. 1973, Preparation and properties of a cholesterol oxidase from *Nocardia* sp. And its application to the enzymatic assay of total cholesterol in serum. *Clinical Chemistry,* **19**: 1350 – 1356.

Robb, A. S. and Dadson, M. J. 2002, Eating disorders in males. *Child and Adolescent Psychiatric Clinics of North America,* **11**: 399-418.

Robinson, C. H. and Weigley, E. S. 1991, Basic Nutrition and Diet Therapy, 6th Ed., Mc.Millan Publishing Company, New York, pp. 278.

Robinson, T. N., 1999, Reducing children's television viewing to prevent obesity: a randomized controlled trial. *Journal of the American Medical Association,* **282**: 1561-1567.

Robinson, T. N., 2001. Television viewing and childhood obesity. *Pediatric Clinics of North America,* **48**: 1017-1025.

Robinson, T. N., Killen, J. D., Kraemer, H. C., *et al.*, 2003. Dance and reducing television viewing to prevent weight gain in African-American girls: the Stanford GEMS pilot study. *Ethnicity and Disease*, **13**: S65–77.

Roeschlau, P., Bernt, E. and Gruber, W., 1974, Enzymatic determination of total cholesterol in serum. *Zeitschrift fur klinische Chemie und klinische Biochemie*, **12**: 226.

Ronnemaa, T., Knip, M., Lautala, P., et al. 1991. Serum insulin and other cardiovascular risk indicators in children, adolescents and young adults. *Annals of Internal Medicine,* **23**: 67–72.

Rorentino, R. F., 2002, The Burden of obesity in Asia Challenges in assessments, prevention and management. *Asian Pacific Journal of Clinical Nutrition,* **11**: 741.

Ross, R., Aru, J., Freeman, J., Hudson, R. and Janssen, I., 2002, Abdominal adiposity and insulin resistance in obese men. *American Journal of Physiology-Endocrinology and Metabolism,* **282**: E657–63.

Ruangdaraganon, N., Kotchabhakdi, N., Udomsubpayakul, U., Kunanusont, C. and Suriyawongpaisal, P., 2002. The association between television viewing and childhood obesity: a national survey in Thailand. *Journal of Medical Association of Thailand,* **85**(Suppl 4): S1075–80.

Rugholm, S., Baker, L. J., Lina, W., Olsen, Nielsen, L.S., Bua, J. and Thorkild, I. A. 2005, Stability of the association between birth weight and childhood overweight during the development of the obesity epidemic. *Obesity Research*, **13**: 2187–2194.

Russell, M., Viner and Cole, T. J., 2005, Adult socioeconomic, educational, social and psychological outcomes of childhood obesity – A national birth cohort study. *British Medical Journal,* **330**: 1354.

Sahota, P., Rudolf, M. C. J., Dixey, R., Hill, A. J., Barth, J. H. and Cade, J., 2001. Evaluation of implementation and effect of primary school based intervention to reduce risk factors for obesity. *British Medical Journal,* **323**: 1027-30.

Sakamato, Y., Gallagher, D., Heymsfield, B., Heo, M., Jebb, S. A. and Murgatroyd, P. R., 2000, Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *American Journal of Clinical Nutrition*, **72**: 694 – 701.

Salbe, A. D., Weyer, C., Lindsay, R. S., Ravussin, E. and Tataranni., P. A., 2002, Assessing risk factors for obesity between childhood and adolescence: I. Birth weight, childhood adiposity, parental obesity, insulin, and leptin. *Pediatrics*, **110**: 299-306.

Sanigorski, A. M., Bell, A. C., Kremer, P. J. and Swinburn, B. A. 2007, High childhood obesity in an Australian population. *Obesity.* **15**: 1908–1912.

Sargent, J. D. and Blanchflower, D. G., 1994, Obesity and stature in adolescents and earnings in young adulthood – Analysis of a British birth cohort. *Archives of Pediatric Adolescent Medicine*, **148**: 681-687.

Sarri, A. and Garcia-Llop, L. A., 1998. Skinfold thickness measurements are better predictors of body fat percentage than body mass index in male Spanish children and adolescents. *European Journal of Clinical Nutrition*, **52**: 573-6.

Sarri, A., Moreno, L. A., Garcia-Llop, L. A., Fleta, J., Morellon, M. P. and Bueno, M., 2001. Body mass index, triceps skinfold and waist circumference in screening for adiposity in male children and adolescents. *Acta Paediatr* **4**: 387-92.

Savva, S. C., Tornaritis, M., Savva, M. E., Kourides, Y., Panagi, A., Silikiotou, N., Georgiou, C. and Kafatos, A., 2000, Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. *International Journal of Obesity and Related Metabolic Disorders*, **24**: 1453-8.

Saxena, K. J., 1986. The joint and nuclear family – A personal experience. *Indian Journal of Social Work*, **18**: 32-36.

Sayeed, M. A., Mahtab, H., Latif, Z. A., Khanam, P. A., Ahsan, K. A., Banu, A. and Khan, A. K., 2003, Waist-to-height ratio is a better obesity index than body mass index and waist-to-hip ratio for predicting diabetes, hypertension and lipidemia. *Bangladesh Medical Research Council Bulletin*, **29**: 1-10.

Schaefer-Graf, U. M., Hartmann, R., Pawliczak, J., Passow, D., Abou-Dakn, M., Vetter, K. and Kordonouri, O., 2006. Association of breast-feeding and early childhood overweight in children from mothers with gestational Diabetes Mellitus. *Diabetes Care*, **29**: 1105-1107.

Segal, K. R., Burastero, S., Chun, A., Coronel, P., Pierson, R. N. Jr., Wang, J., 1991, Estimation of extr acellular and total body water by multiple-frequency bioelectrical-impedance measurement. *American Journal of Clinical Nutrition*, 54: 26-29.

Seidell, J. C. and Bouchard, C., 1997, Visceral fat in relation to health: is it a major culprit or simply an innocent bystander? *International Journal of Obesity Related Metabolic Disorders*, **21**: 626–31.

Seidell, J. C., Kahn, H. S., Williamson, D. F., Lissner, L. and Valdez, R., 2001, Report from a Centers for Disease Control and Prevention Workshop on use of adult anthropometry for public health and primary health care. *American Journal of Clinical Nutrition*, **73**: 123–6.

Seidell, J. C., Verschuren, W. M., van Leer, E. M. and Kromhout, D., 1996, Overweight, underweight, and mortality. A prospective study of 48,287 men and women. *Archives in Internal Medicine*, **156**: 958–963.

Seidman, D. S., Laor, A., Gale, R., Stevenson, D. K., and Danon, Y. L., 1996, A longitudinal study of birth weight and being overweight in late adolescence. *American Journal of Diseases of Children,* **145**: 782-785.

Serdula, M. K., Ivery, D., Coates, R. J., Freedman, D. S., Williamson, D. F. and Byers, S. T., 1993, Do obese children become obese adults? A review of the literature. *Preventive Medicine,* **22**: 167–77.

Shapiro, J. P., Baumeister, R. F. and Kessler, J. W., 1991. A three-component model of children's teasing: aggression, humor, and ambiguity. *Journal of Social and Clinical Psychology*, **10**: 459 –72.

Sharma, A. M. and Chetty, V. T., 2005, Obesity, hyper tension and insulin resistance. *Acta Diabetologica,* **42** (Suppl 1): S3-S8.

Sharma, M. and Singh, M., 2003, Childhood obesity and contributory factors. *Proceedings of IXth Asian Congress of Nutrition – Scientific abstracts,* p.316.

Shen, W., Mark, P., Chen, J., Gallagher, D., Albu, J., Pisunyer, X., Lewis, C. E., Grunfeld, C., Heshka, S. and Heymsfield. S. B. 2006, Waist circumference correlates with metabolic syndrome indicators better than percentage fat. *Obesity.* **14**: 727–736.

Sherwood, N. E., Story, M. and Obarzanek, E., 2004, Correlates of Obesity in African-American Girls: An Overview. *Obesity Research,* **12**: 4S.

Sichieri, R., Coitinho, D. C., Leao, M. M., Recine, E. and Everhart, J. E., 1994. High temporal, geographic and income variation in BMI among adults in Brazil. *American Journal of Public Health*, **84**: 793-798.

SIGN, Scottish Intercollegiate Guideline Network, 1996, *Obesity in Scotland. Integrating Prevention with Weight Management*. A National Clinical Guideline Recommended for Use in Scotland by the Scottish Intercollegiate Guidelines Network, Pilot Edition, Edinburgh, Scotland. Scottish Intercollegiate Guideline Network (SIGN), pp. 1–71.

Sinaiko, A. R., Jacobs, D. R. Jr., Steinberger, J., 2001. Insulin resistance syndrome in childhood: associations of the glycemic insulin clamp and fasting insulin with fatness and other risk factors. *Journal of Pediatrics*, **139**: 700–7.

Singh, A. K. 1997, *Tests, Measurements and Research Methods in Behavioural Sciences*, Bharathi Bhawan Publishers, New Delhi, pp. 293–326.

Singh, J.K., Pandher, A. and Singh, I., 2003, Study of childhood obesity and its management. *Proceedings of IXth Asian Congress of Nutrition– Scientific Abstracts*, p.316.

Singha, S., Goyle, A. and Gupta, R. 1998, Quantitative food frequency questionnaire and assessment of dietary intake. *National Medical Journal of India*, **11**: 268–275.

Singhal, A., Wells, J., Cole, T. J., Fewtrell, M. and Lucas, A., 2003, Programming of lean body mass: A link between birth weight, obesity, and cardiovascular disease? *American Journal of Clinical Nutrition*, **77**: 726-730.

Sinha, R., Fisch, G. and Teague, B., 2002, Prevalence of impaired glucose tolerance among children and adolescents with marked obesity. *New England Journal of Medicine*, **346**: 802–810.

Siri, W. E. 1956, The gross composition of the body. *Advances in Biological and Medical Physics*, **4**: 239-280.

Skybo, T. and Wenger, N. R., 2003, Measures of overweight status in school-age children. *The Journal of School Nursing*, **19**: 172-180.

Slaughter, M. H., Lohman, T. G., Boileau, R. A., Horswill, C. A., Stillman, R. J., Van Loan, M. D. and Bemben, D. A., 1988, Skinfold equations for estimation of body fatness in children and youth. *Human Biology*, **60**: 709–23.

Slee, P. T., 1995. Peer victimization and its relationship to depression among Australian primary school students. *Personality and Individual Differences*. **18**: 57– 62.

Slyper, A. H. 2006a, Childhood obesity, adipose tissue distribution, and the pediatric practitioner. *Pediatrics*, **102**: e4.

Slyper, A. H. 2006b, The pubertal timing controversy in the USA, and a review of possible causative factors for the advance in timing of onset of puberty. *Clinical Endocrinology,* **65**: 1-8.

Smith, C. J. 2004, The current epidemic of childhood obesity and its implications for future coronary heart disease. *Pediatric Clinics of North America*, **51** (6 SPEC. ISS): 1679-1695.

Smoak, C. G., Burke, G. L., Webber, L. S., Harsha, D. W., Srinivasan, S. R. and Berenson, G. S., 1987, Relation of obesity to clustering of cardiovascular risk factors and atherosclerosis in children and young adults. *American Journal of Epidemiology,* **125**: 364–1372.

Sørensen, H. T., Sabroe, S., Rothman, K. J., Gillman, M., Fischer, P. and Sørensen, T. I. A., 1997. Relation between weight and length at birth and body mass index in young adulthood: Cohort study. *British Medical Journal,* **315**: 1137.

Spencer, E. A., Appleby, P. N., Davey, G. K. and Key, T. j., 2003. Diet and body mass index in 38000 EPIC–Oxfod meat eaters, fish eaters, vegetarians and vegans. *International Journal of Obesity*, **27**: 728-734.

Spencer, E. A., Roddam, A. W. and Key, T. J., 2004. Accuracy of self-reported waist and hip measurements in 4492 EPIC-Oxford participants. *Public Health Nutrition*, **7**: 723–7.

Srilakshmi, B. 2004. Nutrition Science. New Age International (p) Ltd., New Delhi. P.55.

Srinivasan, S. R., Bao, W., Wattigney, W. A. and Berenson, G. S. 1996. Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: the Bogalusa Heart Study. *Metabolism*.**45**: 235–40.

Steffen, L. M., Dai, S., Fulton, J. E. and Labarthe, D. R., 2009. Overweight in children and adolescents associated with TV viewing and parental weight: Project HeartBeat. *American Journal of Preventive Medicine*, **37** (1 Suppl): S50-5.

Steinbeck, K. S., 2001, The importance of physical activity in the prevention of overweight and obesity in childhood: a review and an opinion. *Obesity Reviews*, **2**: 117–130.

Stettler, N., Arezoo, Z. and Posner, J. C., 2007. Predictive value of weight-for-age to identify overweight children. *Obesity*, **15**: 3106 –3112.

Stettler, N., Bovet, P., Shamlaye, H., Zemel, B. S., Stallings, V. A., Paccaud, F., 2002b, Prevalence and risk factors for overweight and obesity in children from Seychelles, a country in rapid transition: the importance of early growth. *International Journal of Obesity Related Metabolic Disorders,* **26**: 214 –219.

Stettler, N., Kumanyika, S. K., Katz, S. H., Zemel, B. S. and Stallings, V. A., 2003, Rapid weight gain during infancy and obesity in young adulthood in a cohort of African Americans. *American Journal of Clinical Nutrition,* **77**: 1374–1378.

Stettler, N., Zemel, B. S., Kumanyika, S. and Stallings, V. A. 2002a, Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics,* **109**: 194 –199.

Stevens, J., Kumanyika, S. K. and Keil, J. E., 1994, Attitudes toward body size and dieting: differences between elderly black and white women. *American Journal of Public Health,* **84**: 1322–1325.

Stevens, J., Suchindran, C., Ring, K., Baggett, C. D., Jobe, J. B., Story, M., Thompson, J., Going, S. B. and Caballero, B., 2004, Physical activity as a predictor of body composition in American Indian children. *Obesity Research,* **12**: 1974 –1980.

Stic, E., Cameron, R. P., Killen, J. D., Hayward, C. and Taylor, C. B., 1999, Naturalistic weight reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. *Journal of Consulting and Clinical Psychology,* **67**: 967–974.

Stoll, B. A. 1998, Teenage obesity in relation to breast cancer risk. *International Journal of Obesity,* **22**: 1035-1040.

Story, M., Evans, M., Fabsitz, R., Clay, T., Holyrock, B. and Broussard, B., 1999, The epidemic of obesity in American Indian communities and the need for childhood obesity-prevention programs. *American Journal of Clinical Nutrition*, **69** (Suppl): 747–54S.

Stunkard, A. J., Faith, M. S. and Allison, K. C. 2003, Depression and obesity. *Biological Psychiatry*, **54**: 330-337.

Sugarman, S. D. and Sandman, N., 2008. Using performance-based regulation to reduce childhood obesity. *Australia and New Zealand Health Policy*, **5**: 26.

Suman, K. T., 2000. Effect of amaranth on the health and nutritional profile of adolescents. M.Sc. (Home Science) Thesis, Kerala Agricultural University, Thrissur, India. pp.88.

Swaminathan, M. 2004, *Advanced Text Book on Food and Nutrition. Vol II - Applied Aspects*. Bangalore Printing and Publishing Company Limited, India, pp. 336–368.

Sweeting, H. N. 2007, Measurement and definitions of obesity in childhood and adolescence: A field guide for the uninitiated. *Nutrition Journal*, **6**: 32.

Swinburn, B. A., Caterson, I., Seidell, J. C. and James, W. P., 2000, Diet, nutrition and the prevention of excess weight gain and obesity. *Public Health Nutrition*, **7**: 123– 146.

Taveras, E. M., Rifas-Shiman, S. L., Scanlon, K. S., Grummer-Strawn, L. M., Sherry, B. and Gillman, M. W., 2006. To what extent is the protective effect of breastfeeding on future overweight explained by decreased maternal feeding restriction? *Pediatrics*, **118**: 2341-2348.

Taylor, R. W., Jones, I. E., Williams, S. M. and Goulding, A., 2000, Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3–19 y. *American Journal of Clinical Nutrition,* **72**: 490 –5.

Taylor, R. W., Keil, D., Gold, E. J. and Williams, S. M., Goulding, A., 1998, Body mass index, waist girth, and waist-to-hip ratio as indexes of total and regional adiposity in women: evaluation using receiver operating characteristic curves. *American Journal of Clinical Nutrition,* **67**: 44–9.

Thimmayamma, B. V. S. 1987, A Handbook of Schedules and Guidelines in Socioeconomic and Diet Surveys. National Institute of Nutrition, Hyderabad, pp. 1–70.

Thimmayamma, B. V. S. and Rao, P. 1996, Dietary assessment as part of nutritional status. In: *Text Book of Human Nutrition,* Bamji, M. S., Rao, N. P. and Reddy, V. (Eds.), Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 125-135.

Thompson, J. K., Coovert, M. D., Richards, K. J., Johnson, S. and Cattarin, J. 1995, Development of body image, eating disturbance, and general psychological functioning in female adolescents: covariance structure modeling and longitudinal investigations. *International Journal of Eating Disorders,* **18**: 221–36.

Tones, K., 1996. The health promoting school: some reflections on evaluation. *Health Education and Research,* **11**: i-viii.

Toriano, R. P., Flegal, K. M., Kucsmarski, R. J., Campbell, S. J. and Johnson, C. L., 1995, Overweight prevalence and trends for children and adolescents. *Archives in Paediatric and Adolescent Medicine,* **149**: 1085-1091.

Toschke, A. M., Grote, V., Koletzko, B. and von Kries, R. 2004, Identifying children at high risk for overweight at school entry by weight gain during the first 2 years. *Archives in Pediatric and Adolescent Medicine,* **158**: 449 –52.

Toschke, A. M., Martin, R. M., von Kries, R., Wells, J., Smith, D. G. and Ness, A. R., 2007. Infant feeding method and obesity: body mass index and dual-energy X-ray absorptiometry measurements at 9-10 y of age from the Avon Longitudinal Study of Parents and Children (ALSPAC). *American Journal of Clinical Nutrition,* **85**: 1578-1585.

Toschke, A. M., Vignerova, J., Lhotska, L., Osancova, K., Koletzko, B., von Kries, R., 2003. Overweight and obesity in 6- to 14-year-old Czech children in 1991: Protective effect of breast-feeding. *Obstetrical and Gynecological Survey,* **58**: 379-380.

Toth, M. J., Sites, C. K., Cefalu, W. T., Matthews, D. E. and Poehlman, E. T., 2001, Determinants of insulin-stimulated glucose disposal in middle-aged, premenopausal women. *American Journal Physiology Endocrinology Metabolism,* **281**: E113–21.

Tremblay, M. S. and Willms, J. D., 2003. Is the Canadian childhood obesity epidemic related to physical inactivity? *International Journal of Obesity and Related Metabolic Disorders,* **27**: 1100–5.

Trinder, P., 1969, Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. *Annals of Clinical Biochemistry,* **6**: 24 - 28.

Troiano, R. P., Briefel, R.R., Carroll, M.D. and Bialostosky, K. 2000, Energy and fat intakes of children and adolescents in the United States: data from the National Health and Nutrition Examination Surveys. *American Journal of Clinical Nutrition.* **72**: 1343–53.

Troiano, R. P., Flegal, K. M., Kuczmarski, R. J. 1995. Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. *Archives in Pediatric and Adolescent Medicine*, **149**: 1085-1091.

Trost, S. G., Sirard, J. R., Dowda, M., Pfeiffer, K. A. and Pate, R. R., 2003, Physical activity in overweight and non-overweight preschool children. *International Journal of Obesity Related Metabolic Disorders,* **27**: 834–839.

Udaya, P. K., 1996. Food consumption pattern and nutritional status of farm women in Thrissur district. M. Sc. (Home Science) Thesis, Kerala Agricultural University, Thrissur, India, pp.83.

UNICEF, 1991. The world summit for children, a global event. UNICEF – Annual Report, 5-10

Unnithan, A. G. and Syamakumari, S., 2008, Prevalence of overweight, obesity and underweight among school going children in rural and urban areas of Thiruvananthapuram educational district, Kerala state (India). *The Internet Journal of Nutrition and Wellness,* **6**: 2.

US Preventive Services Task Force, 2005.Screening and interventions for overweight in children and adolescents: recommendation statement. *Pediatrics* **116:**205-209.

Vague, J., 1956, The degree of masculine differentiation of obesities: A factor determining predisposition to diabetes, atherosclerosis, gout and uric calculous disease. *American Journal of Clinical Nutrition,* **4**: 20.

Valdez, R., Seidell, J. C., Ahn, Y. I. and Weiss, K. M., 1993, A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A cross population study. *International Journal of Obesity and Related Metabolic Disorders,* **17**: 77-82.

Vandegrift, D. and Yoked, T., 2004. Obesity rates, income and suburban sprawl: An analysis of US states. *Health and Place*, **10**: 221-229.

Vandewater, E. A., Shim, M. and Caplovitz, A. G., 2004. Linking obesity and activity level with children's television and video game use. *Journal of Adolescence,* **27**: 77-85.

Varghese, R. T. and Vijayakumar, K., 2008, Prevalence pattern of obesity across different age groups in rural settings of Kerala. *Calicut Medical Journal,* **6**: e3 1-4.

Varley, H. 1988, *Practical Clinical Biochemistry*. William Heinemann Medical Books Ltd., London, pp.31-39.

Verhulst, S. L., Schrauwen, N., Haentjens, D., Rooman, R. P., Van Gaal, L., De Backer, W. A. and Desager, K. N., 2008, Sleep-disordered breathing and systemic inflammation in overweight children and adolescents. *International Journal of Paediatric Obesity*, **3**: 234 – 239.

Vijayalakshmi, P. and Rao, K. C., 1988. Assessment of nutritional status of tribal children (0-12 years) of Maredumilli block by anthropometry. *Indian Journal of Nutrtion and Dietetics,* **25**: 182-185.

Vijayalakshmi, R., Sohba, I. and Reddy, M. S. N. 2003, Social nutrition and elderly. *Social Welfare,* **46**: 10-18.

Vik, T., Jacobsen, G., Vatten, L. and Bakketeig, L. S., 1996, Pre- and post-natal growth in children of women who smoked in pregnancy. *Early Human Development,* **45**: 245–255.

Viner, R. 2002, Is puberty getting earlier in girls? *Archives of Disease in Childhood,* **86**: 10-12.

Viner, R. M. and Cole, T. J., 2005. Adult socioeconomic, educational, social, and psychological outcomes of childhood obesity: a national birth cohort study. *British Medical Journal,* **330**: 1354-5.

Visscher, T. L., Seidell, J. C. and Menotti, A., 2000, Underweight and overweight in relation to mortality among men aged 40–59 and 50–69 years: the Seven Countries Study. *American Journal of Epidemiology,* **151**: 660–666.

Vlierberghe, L. V., Braet, C., Goossens, L., Rosseel, Y. and Mels, S., 2009. Psychological disorder, symptom severity and weight loss in inpatient adolescent obesity treatment. *International Journal of Paediatric Obesity,* **4:** 36-44.

von Kries, R., Koletzko, B., Sauerwald, T. and von Mutius, E., 2000. Does breast-feeding protect against childhood obesity? *Advances in Experimental Medical Biology*, 478: 29-39.

von Kries, R., Koletzko, B., Sauerwald, T., von Mutius, E., Barnert, D., Grunert, V. and von Voss, H. 1999a, Breast feeding and obesity: cross sectional study. *British Medical Journal,* **319**:147–50.

von Kries, R., Toschke, A. M., Koletzko, B. and Slikker, W. Jr., 1999b, Maternal smoking during pregnancy and childhood obesity. *American Journal of Epidemiology,* **156**: 954–61.

Wadsworth, M., Marshall, S., Hardy, R., Paul, A. and Hebebrand, J., 1999. Breast feeding and obesity. *British Medical Journal*, **319**: 1576.

Wagner, A., Simon, C., Ducimetiere, P., 2001. Leisure-time physical activity and regular walking or cycling to work are associated with adiposity and 5 y weight gain in middle-aged men: the PRIME Study. *International Journal of Obesity and Related Metabolic Disorders,* **25**: 940–8.

Wang, J., Thornton, J. C., Kolesnik, S. and Pierson, R. N. Jr., 2000. Anthropometry in body composition: An overview. *Annals of New York Academy of Sciences,* **904**: 317-326.

Wang, L. Y., Yang, Q., Lowry, R. and Wechsler, H., 2003, Economic analysis of a school-based obesity prevention program. *Obesity Research,* **11**: 1313–1324.

Wang, Y. 2004, Epidemiology of childhood obesity – methodological aspects and guidelines: what is new? *International Journal of Obesity & Related Metabolic Disorders,* **28** (Suppl. 3): S21-28.

Wang, Y. and Lobstein, T. 2006, Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity,* **1**: 11–25.

Wardle, J. and Cooke, L. 2005, The impact of obesity on psychological well-being. *Best Practice & Research Clinical Endocrinology & Metabolism,* **19** (3 Spec. iss): 421-440.

Wareham, N. J., van Sluijs, E. M. F. and Ekelund, U. 2005, Physical activity and obesity prevention: a review of the current evidence. *Proceedings of the Nutrition Society*, **64**: 229-247.

Waterlow, J. C. 1972, Classification and definition of protein calorie malnutrition. *British Medical Journal*, **3**: 566-9.

Wattigney, W. A., Harsha, D. W., Srinivasan, S. R., Webber, L. S. and Berenson, G. S., 1991. Increasing impact of obesity on serum lipids and lipoproteins in young adults. The Bogalusa Heart Study. *Archives of International Medicine*. **151**: 2017–22.

Wei, M., Gaskill, S. P., Haffner, S. M. and Stern, M. P., 1997, Waist circumference as the best predictor of noninsulin dependent diabetes mellitus (type 2 diabetes) compared with body mass index, waist/hip ratio and other anthropometric measurements in Mexican Americans: a 7-year prospective study. *Obesity Research*, **5**: 16–23.

Weisberg, S. P., McCann, D., Desai, M., Rosenbaum, M., Leibel, R. L. and Ferrante, A. W., 2003. Obesity is associated with macrophage accumulation in adipose tissue. *The Journal of Clinical Investigation*, **112**: 1796-1808.

Weker, H. 2006. Simple obesity in children. A study on the role of nutritional factors. *Med Wieku Rozwoj*. **10**: 3-191.

Welk, G. J., Corbin, C. B. and Dale, D., 2000. Measurement issues in the assessment of physical activity in children. *Research Quarterly Exercise Sports*, **71**(2 suppl.): S59–73.

Wells, J. C. K., 2001. A critique of the expression of paediatric body composition data. *Arch Dis Child.*, **85**: 67-72.

Wells, J. C. K., Hallal, P. C., Reichert, F. F., Menezes, A. M. B., Araujo, C. L. P. and Victora, C. G., 2008. Sleep patterns and television viewing in relation to obesity and blood pressure: evidence from an adolescent Brazilian birth cohort. *International Journal of Obesity*, **32**: 1042-1049.

Werner, M., Gabreelson, D. G. and Eastman, G. 1981, *Clinical Chemistry,* William Heinemann Medical Books Ltd., London, pp. 268.

Whitaker, R. C., Wright, J. A., Pepe, M. S., Seidel, K. D. and Dietz, W. H., 1997, Predicting obesity in young adulthood from childhood and parental obesity. *New England Journal of Medicine,* **337**: 869–873.

Whitaker, R.C. and Dietz, W.H., 1998, Role of prenatal environment in the development of obesity. *Journal of Pediatrics,* **132**: 768-76.

Whitehead, R. G., 1995, For how long is exclusive breast-feeding adequate to satisfy the dietary energy needs of the average young baby? *Pediatric Research,* **37**: 239-43.

WHO, World Health Organisation, 1995, Physical status- The Use and Interpretation of Anthropometry, *World Health Organization Technical Report Series,* **854**: 12-18.

WHO, World Health Organisation, 1987, *Nutrition Monitoring and Assessment,* Eds., Gopaldas, T. and Seshadri, S., Oxford University press, pp. 105.

WHO, World Health Organization, 1998, *Obesity: Preventing and Managing the Global Epidemic*, Report of a WHO Consultation, Geneva 3-5 June 1997. Geneva: WHO, (WHO/NUT/98.1).

WHO, World Health Organization, 2000, Obesity: Preventing and Managing the Global Epidemic - Report of a WHO Consultation. *World Health Organization Technical Report Series,* **894**: 5–15.

WHO, World Health Organization, 2007, *The World Health Report – 2007*, A Safer Future: Global Public Health Security in the Twenty First Century, Vienna, pp. 318-331.

Wichstrom, L. 1995, Social, psychological and physical correlates of eating problems. A study of the general adolescent population in Norway. *Psychological Medicine*, **25**: 567-580.

Willet, W. C., Dietz, W. H. and Colditz, G. A. 1998, Guide lines for healthy weight. *The New England Journal of Medicine*, **341**: 427 -34.

Williams, D. P., Going, S. B., Lohman, T. G., Harsha, D. W., Srinivasan, S. R., Webber, L. S. and Berenson, G. S. 1992, Body fatness and risk for elevated blood-pressure, total cholesterol, and serum-lipoprotein ratios in children and adolescents. *American Journal of Public Health,* **82**: 358-363.

Williamson A. 1994. Factors affecting the development of an appropriate curriculum to promote physical activity in 3-5 year old children in Glasgow pre five establishments. M. Ed. Thesis, University of Glasgow.

Wolf, A. M. and Colditz, G. A., 1998, Current estimates of the economic cost of obesity in the United States. *Obesity Research,* **6**: 97–106.

Wolf, A.M. and Colditz, G.A., 1996, Social and economic effects of body weight in the United States. *American Journal of Clinical Nutrition,* **63**: 466S–9S.

Wolff, O. H., 1955, Obesity in childhood: A study of the birth weight, the height, and the onset of puberty. *QJM*, **24**: 109-123.

Womersley, J. 1977, A comparison of the skin fold method with extent of overweight and various weight height relationships in the assessment of obesity. *British Journal of Nutrition*, 38: 271 – 284.

Wright, C.M., Parker, L., Lamont, D. and Craft, A.W., 2001. Implications of childhood obesity for adult health: findings from thousand families cohort study. *British Medical Journal*, **323**: 1280-4.

Yadav, Y. and Kumar, S., 2006, The food habits of a nation. The Hindu, August 14, 2006, Front Page Supplement, Chennai Edition, India. Available at http://www.hindu.com/2006/08/14/stories/2006081403771200.htm

Yan, W., Bingxian, H., Hua, Y., Jianghong, D., Jun, C., Dongliang, G., Yujian, Z., Ling, L., Yanying, G., Kaiti, X., Xiaohai, F. and Da, M., 2007, Waist-to-height ratio is an accurate and easier index for evaluating obesity in children and adolescents. *Obesity.* **15**: 748 –752.

Yannakoulia, M., Panagiotakos, D. B., Pitsavos, C. and Stefanadis, C., 2006. Correlates of BMI misreporting among apparently healthy individuals: the ATTICA study. *Obesity.* **14**: 894 –901.

Young, T. K., Dean, H. J., Flett, B. and Wood-Steiman, P., 2000, Childhood obesity in a population at high risk for type 2 diabetes. *Journal of Pediatrics,* **136**: 365–369.

Young-Hyman, D., Schlundt, D. G., De Luca, F. and Counts, D., 2001. Evaluation of the insulin resistance syndrome in 5- to 10-year old overweight/obese African-American children. *Diabetes Care*, **24**: 1359–64.

Zannolli, R. and Morgese, G., 1996, Waist percentiles: a simple test for artherogenic disease? *Acta Paediatr,* **85**: 1368-1369.

Zhou, B., Wu, Y., Yang, J., Zhang, H. and Zhao, L., 2002, Overweight is an independent factor for cardiovascular disease in Chinese populations. *Obesity Reviews,* **3**: 147–56.

Zhu, S., Heshka, S., Wang, Z., Shen, W., Allison, D. B., Ross, R. and Heymsfield, S. B., 2004. Combination of BMI and waist circumference for identifying cardiovascular risk factors in whites. *Obesity Research,* **12**: 633– 645.

Zhu, S., Wang, Z., Heshka, S., Heo, M., Faith, M. S. and Heymsfield, S. B., 2002, Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey: clinical action thresholds. *American Journal of Clinical Nutrition,* **76**: 743–9.

Appendix – I

STATISTICS ON THE NUMBER OF SCHOOLS IN THRISSUR DISTRICT, KERALA STATE

Sl. No.	Schools	Government	Government Aided Private	Unaided Private	Total
1	Higher Secondary Schools	26	11	2	39
2	High Schools	58	139	19	216
3	**Upper Primary Schools**	**56**	**164**	**8**	**228**
4	**Lower Primary Schools**	**121**	**390**	**10**	**521**
5	Training Schools	2	7	0	9
Total		263	711	39	1013

Appendix – II

SCHEDULE USED FOR OBESITY SCREENING SURVEY

1. Name of the head of the family:
2. Address :
3. Age of the respondent :
4. Type of family :
5. Name of the respondent :
6. Age and date of birth :
7. Gender : Boy / Girl
8. Community : General / OBC / SC/ST
9. Socio-economic background of the family

S.No	Members	Age (years)	Gender	Education	Occupation	Income (Rs/month)

10. Birth weight of the child :
11. Birth order of the child :
12. Parental age at marriage :

Father

Mother

13. Age at delivery

Age

18 - 20

20 - 22

23 - 25

26 – 28

29 - 31

>31

14. Breast feeding practices

(i)Breastfeeding

Yes

No

(ii)If yes, duration

<3months

3-6 months

7– 12 months

1 – 2years

>2 years

15. Parental history of obesity

Father : Yes/ No

Mother : Yes/ No

16. Anthropometric data

S. No	Particulars (units)	Measurement
1	Height (cm)	
2	Weight (kg)	
3	Waist circumference (cm)	
4	Hip circumference (cm)	
5	Mid upper arm circumference (MUAC in cm)	
6	Skinfold thickness	
	• Fat fold at triceps (mm)	
	• Fat fold at biceps (mm)	
	• Fat fold at sub scapular (mm)	
	• Fat fold at abdomen (mm)	
7	BMI	
8	Waist to hip ratio	
9	Body density	
10	Body fat percentage	
11	Lean body mass	

Appendix – III

REFERENCE VALUES / STANDARDS FOR COMPARISON OF HEIGHT AND WEIGHT

I. NCHS standards for height and weight of school going children

Age (Years)	Height (cm)		Weight (kg)	
	Boys	Girls	Boys	Girls
7	121.7	120.6	22.9	21.8
8	127	126.4	25.3	24.8
9	132.2	132.2	28.1	28.5
10	137.5	138.3	32.5	31.4
11	143.3	144.8	35.3	37
12	149.7	151.5	39.8	41.5

Ref. (ICMR, 1990)

II. Weight for age classification

Class	Nutritional Status
≤ 60 % weight for age	Grade III Malnutrition
61 – 75 % weight for age	Grade II Malnutrition
76 – 90% weight for age	Grade I Malnutrition
>90 % weight for age	Normal

Ref. Gomez *et al*., 1956

III. Height for age classification

Class	Nutritional Status
< 85 % expected height for age	Severe Malnutrition
85 – 90 % expected height for age	Moderate Malnutrition
90 – 95% expected height for age	Marginal Malnutrition
>95 % expected height for age	Normal

Ref. Waterlow, 1972

Appendix – IV

BMI CUT-OFF POINTS - NATIONAL/INTERNATIONAL STANDARDS

(I) Classification of nutritional status based on BMI

BMI	Nutritional status
<16.0	Chronic energy deficiency (CED) – Grade III
16.0 – 17.0	CED – Grade II
17.0 – 18.5	CED – Grade I
18.5 – 20.0	Low Normal
20.0 – 25	Normal
25.0 – 30.0	Obese – Grade I
>30.0	Obese – Grade II

Ref. (James *et al*., 1988)

(II) International cut off points of BMI for school children

Age (Years)	BMI (overweight)		BMI (obese)	
	Boys	Girls	Boys	Girls
7.0	17.9	17.8	20.6	20.5
7.5	18.2	18	21.1	21
8.0	18.4	18.3	21.6	21.6
8.5	18.8	18.7	22.2	22.2
9.0	19.1	19.1	22.8	22.8

9.5	19.5	19.5	23.4	23.5
10.0	19.8	19.9	24	24.1
10.5	20.2	20.3	24.6	24.8
11.0	20.6	20.7	25.1	25.4
11.5	20.9	21.2	25.6	26.1
12.0	21.2	21.7	26	26.7

Ref. Cole *et al*. (2000)

(III) Classification of nutritional status based on the CDC percentiles values

Underweight, less than the 5th percentile

Healthy weight, 5th percentile up to the 85th percentile

Overweight, 85th to less than the 95th percentile

Obese, equal to or greater than the 95th percentile

(IV) BMI cut-off points for Indian children

Age	BMI (overweight)		BMI (obese)	
(Years)	Boys	Girls	Boys	Girls
7.0	16.4	18.8	16.8	19.9
7.5	16.7	19.3	17.1	20.5
8.0	17	19.9	17.5	21.0
8.5	17.2	20.5	18.0	21.5
9.0	17.6	21.0	18.5	22.1
9.5	17.9	21.6	19.1	22.7
10.0	18.2	22.0	19.6	23.2
10.5	18.4	22.6	20.2	23.9
11.0	18.9	23.1	20.8	24.5
11.5	19.3	23.7	21.2	25.1
12.0	19.8	24.1	21.8	25.7

Ref. Khadilkar *et al.*, 2007

APPENDIX – V

WAIST CIRCUMFERENCE PERCENTILES

Waist circumference percentiles for obese and overweight children according to age and gender

Age	BMI (overweight)		BMI (obese)	
(Years)	Boys	Girls	Boys	Girls
7.0	58.8	58.7	60.7	60.8
8.0	60.9	60.4	62.9	62.7
9.0	63.2	62.0	65.4	64.5
10.0	65.6	63.6	67.9	66.2
11.0	67.9	65.4	70.4	68.1
12.0	70.4	67.3	72.9	70.5

Ref. McCarthy *et al*. (2001)

APPENDIX -VI

INTERVIEW SCHEDULE TO ELICIT INFORMATION ON SOCIO-ECONOMIC CONDITIONS AND ACTIVITY PROFILE OF THE SAMPLE

1. Name of head of the family :
2. Address :
3. Place of survey :
4. Age of the respondent :
5. Type of family : Joint / Nuclear
6. Family size : No. of adults / children
7. Religion : Hindu
   Christian
   Muslim
   SC/ST
8. Educational levels :Illiterate/ LPS/ UPS/ High school/ College
   Father :
   Mother :
9. Occupational status :
   Father : Permanent job
   Temporary job
   Agriculture
   Business
   Labourers
   Unemployed

   Mother : Permanent job
   Temporary job
   Agriculture
   Business
   Labourers
   Unemployed
10. Monthly income of the family: Up to 2000 Rs
    Rs 2001 – 6000
    Rs 6001 – 10,000
    Rs 10,001 – 20,000
    Rs 20,001 – 30,000

11. Monthly expenditure pattern

Sl. No.	Item	Expenditure monthly (Approximately)
1.	Food	
2.	Clothing	
3.	Shelter	
4.	Rent	
5.	Transport	
6.	Education	
7.	Entertainment	
8.	Savings	
9.	Health	
10.	Own expenses	
11.	Repayment of loans	
12.	Kuries	
13.	Fuels	
14.	Others	

12. Details on Housing conditions

Sl. No.	**Parameter**	**Variants**
1	Ownership of house	Own Rented
2	Number of rooms	1 -2 3 -5 6 – 8 >8
3	Type of roof	Thatched Tiled
4	Separate rooms for children	Yes No

13. Availability of essential services

1. Source of drinking water
   Own well
   Public tap
   Others
2. Lavatory facilities
   Yes
   No
3. Drainage facilities
   Present
   Absent
4. Electricity
   Present
   Absent
5. Information source / Recreational facilities

   Television
   Computer (Internet)
   Radio
   Newspaper
6. Labour saving devices
   Yes
   No

14. Morbidity pattern (Details of epidemic that had affected the selected child during the past one year)

Disease	**Duration**			**Treatment**
	Very often	Sometimes	Not at all	
Diarrhoea/ vomiting				
Measles				
Chicken pox				
Mumps				
Fever				
Jaundice				
Respiratory diseases				
Others specify				

15. Child's (sample) involvement in household duties : Yes/ No

If Yes, Frequency : Daily/ Holidays/ Never

Washing clothes (D, H, N)

Washing utensils (D, H, N)

Purchasing items (D, H, N)

Sweeping (D, H, N)

16. Participation in sports and games : Yes/ No

If yes, type of game preferred : Indoor/ outdoor/ both

Frequency : Daily/ Holidays/ Never

Duration : < 30 mts

30 mts – 1 hr

1 hr – 2 hr

> 2 hr

17. Habit of viewing television : Yes/ No

If yes, Frequency : Daily/ Holidays/ Never

Duration : < 30 mts

30 mts – 1 hr

1 hr – 2 hr

> 2 hr

18. Habit of playing computer games : Yes/ No

If yes, frequency : Daily/ Holidays/ Never

Duration : < 30 mts

30 mts – 1 hr

1 hr – 2 hr

> 2 hr

19. Mode of travel to school : Walking, cycling, Bus, Others

20. Distance of travel to school :

Appendix – VII

INTERVIEW SCHEDULE TO ELICIT INFORMATION ON DIETARY HABITS AND PRACTICES OF THE FAMILY AND THE SAMPLE

1. Name of the house wife :
2. Meal pattern of the family : One major meal
   Two major meals
   Three major meals
   More than three

3. Food expenditure pattern :

Sl. No.	Food stuff	Amount spend per month
1.	Cereals	
2.	Pulses	
3.	Other vegetables	
4.	Green leafy vegetables	
5.	Roots and tubers	
6.	Meat	
7.	Chicken	
8.	Fish	
9.	Egg	
10.	Fruits	
11.	Milk	

4. Do the family members have a specific time schedule for taking food : Yes/ No

5. Frequency of use of different foods by the sample

Foods	Daily	Frequency of use weekly				Occasionally	Never
		Once	Twice	Thrice	Four times		
1.Cereals							
2.Pulses							
3.Green leafy vegetables							
4.Roots and tubers							
5.Other vegetables							
6.Fruits							
7.Milk and milk products							
8.Meat							
9.Fish							
10.Egg							
11.Fats and Oils							
12.Sugar and jaggery							

6. Frequency of purchase and use of processed foods

Foods	Daily	Frequency (Weekly)				Occasionally	Never
		Once	Twice	Thrice	Four times		
1.Ready to cook foods							
2. Beverages							
3. Bakery items							
4. Fried foods							
5. Processed foods							

7. Do you purchase any ready-to-eat food : Yes/ No

If yes, what type of food purchased: Veg/ Non veg/ Both

Source of purchase : Hotels/ bakery/ Fast food centres

8. Reasons of purchase :

9. Do you prepare special foods for children : Yes/ No

If yes, specify

10. Does your child like home made foods: Yes/ No

If yes, what type of preparations?

Eating habits of the selected child

11. Food habit : Veg/ Non veg

12. Meal pattern : One major meal

Two major meals

Three major meals

13. Does your child take breakfast regularly : Yes/ No

If No, reason

14. Does your child have the habit of taking lunch regularly : Yes/ No

If No, reason

15. Does your child take packed lunch to school : Yes/ No

If yes, what type of food: Bread

Rice

Chapathi

Breakfast items

Any other

If no, Source and type of levels preferred (order of preference): School canteen

Street vendor

Any other

16. Does your child have the habit of taking dinner: Yes/ No

If No, reason

17. Does your child like fried foods: Yes/ No

18. Does your child have the habit of taking snacks in between meals: Yes/ No

If yes, type of foods

19. Does your child have the habit of nibbling while watching TV or playing computer games : Yes/ No

If yes, regularly / once in a while

If yes, mention the type of food taken: Chips
Nuts
Fruits
Chocolates
Any other, specify

20. Does your child consume raw foods / salads regularly : Yes/ No

If yes, mention type of raw foods preferred by your child: Raw vegetable salad
Fruits
Others

21. Does your child have a specific time schedule for taking food: Yes/ No

22. Does they take food along with family members : Yes/ No

23. Does your child like to take food from outside : Yes/ No

If yes: Veg/ Non veg

From where: Hotels/ Bakery/ Fast food centres

Frequency: Monthly/ Weekly/ Daily

Mention types of food preferred by your child

24. Is your child weight conscious: Yes/ No

If yes, mention the weight management technique used: Diet control
Skipping meals
Exercise
Walking
Cycling
Any other
None

25. Time spent on the above activities in a day:

<15 mts/ 15 mts/ 30 mts/ 1 hr/ 2 hr/ >2hrs

Appendix VIII

DIETARY RECALL SCHEDULE

Name :

Age :

Gender :

Food consumption

Name of the meal	Method	Weight of total raw ingredients used by the family (g)	Weight of total cooked food consumed by the family (g)	Amount of cooked food consumed by the individual (g)	Raw equivalents used by the individuals

Foods consumed

Food stuff	Amount consumed (gm)
1. Cereals and Millets a. Rice b. Wheat c. Other grains d. Other cereal or starchy foods e. Processed cereal foods	

2. Pulses and nuts a. Dals b. Whole legumes c. Groundnut d. Other nuts e. Parched legumes	
3. Vegetables a. Leafy vegetables b. Roots and tubers c. Others	
4. Animal foods a. Fish, meat and chicken b. Egg	
5. Milk and milk products a. Whole milk b. Toned milk c. Milk powder d. Curd e. Cheese f. Ice cream g. Other milk products	
6. Fats and oils a. Butter b. Dalda c. Groundnut oil d. Ghee e. Refined oils f. Other oil (specify)	

7. Sugar a. Refined sugar b. Jaggery c. Others (honey, molasses etc)	
8. Condiments a. Tamarind b. Cocum c. Chillies d. Other spices	
9. Preserved and processed foods a. Pickles b. Papad c. Jams and Jellies d. Other canned or bottled foods	
10. Beverages a. Tea b. Coffee c. Cocoa d. Carbonated drinks	

Appendix IX

SCHEDULE TO ELICIT CLINICAL DATA

Name :

Age :

Gender :

1. Hair

Lack of luster

Thinness and sparseness

Straightness

Dyspigmentation

Easy pluckability

1. Face

Diffuse depigmentation

Naso-labial dyssebacea

Moon face

3. Eyes

Pale conjunctiva

Bitots spot

Conjuctival Xerosis

Corneal Xerosis

Keratomalacia

Angular palpebritis

4. Lips

Angular stomatitis

Angular scars

Cheilosis

5. Tongue

Oedema

Scarlet and raw tongue

Magenta tongue

Atrophic papillae

6. Teeth

Mottled enamel

7. Gums

Spongy bleeding gums

8. Glands

Thyroid enlargement

Parotid enlargement

9. Skin

Xerosis

Follicular hyperkeratosis

Petechiae

Pellagrous dermatosis

Flaky paint dermatosis

10. Nails

Koilonychia

11. Subcutaneous tissue

Oedema

Amount of subcutaneous fat

Others (Specify, if any):

Name of doctor:

Signature:

Appendix – X

SCHEDULE TO RECORD BIOCHEMICAL DATA

Name :

Age :

Gender :

Lipid profile	**Values**
Serum cholesterol (mg/dl)	
Serum triglyceride (mg/dl)	
HDL (mg/dl)	
LDL (mg/dl)	
VLDL (mg/dl)	
Blood haemoglobin level (mg/dl)	
Blood pressure	
Systolic BP (mg/dl)	
Diastolic BP (mg/dl)	

APPENDIX – XI

PROCEDURES USED FOR BIOCHEMICAL ANALYSIS

LIPID PROFILE

(I) SERUM CHOLESTEROL

Assay kit is obtained from Randox Laboratories

Assay Principle

The cholesterol is determined after enzymatic hydrolysis and oxidation. The indicator quinoneimine is formed from hydrogen peroxide and 4–aminoantipyrine in the presence of phenol and peroxidase.

$$\text{Cholesterol ester} + H_2O \xrightarrow{\text{Cholesterol Esterase}} \text{Cholesterol} + \text{Fatty acids}$$

$$\text{Cholesterol} + O_2 \xrightarrow[\text{Oxidase}]{} \text{4 - Cholesten -3-one} + H_2O_2$$

$$2\ H_2O_2 + \text{phenol} + \text{4 – Amino antipyrine} \xrightarrow{\text{Peroxidase}} \text{Quinoneimine} + 4\ H_2O$$

Reagent Composition

Contents	Initial Concentration of Solution
1.Reagent	
4 – Aminoantipyrine	0.03 mmol/L
Phenol	6 mmol/L
Peroxidase	$\geq$ 0.5 U/ml
Cholesterol Esterase	$\geq$ 0.15 U/ml
Cholesterol Oxidase	$\geq$ 0.1 U/ml
Pipes Buffer	80 m mol/L; pH 6.8
Standard	**5.17 mmol/L (200 mg/dl)**

Preparation of Reagent

Reagent

Contents ready for use. The reagent is stable upto expiry date, when stored at +2^{o}C to +8^{o}C, in the absence of contamination, protected from light.

Standard

Contents ready for use. Stable up to the expiry date when stored at +2^{o}C to +8^{o}C

Procedure

1000 µl (1ml) reagent is incubated with 10 µl sample for 10 minutes at 37^{o} C. A standard is also run simultaneously with the test. The final colour is read at 546 nm.

$$\text{Calculation} = \frac{\text{Optical density of test x Concentration of standard (200mg)}}{\text{Optical density of standard}}$$

References

Richmond (1973); Roeschlau *et al*. (1974); Trinder (1969); NCEP (1988)

(II). TRIGLYCERIDES

Principle

Enzymatic determination of triglycerides according to the following reactions:

$$\text{Triglycerides} + H_2O \xrightarrow{\text{Lipoprotein lipase}} \text{Glycerol + Fatty acid}$$

$$\text{Glycerol + ATP} \xrightarrow[Mg^{++}]{\text{Glycerol kinase}} \text{Glycerol – 3 – phosphate + ADP}$$

$$\text{Glycerol – 3 – phosphate} + O_2 \xrightarrow{\text{GPO}} \text{Dehydroxyacetone phosphate} + H_2O_2$$

$$2\ H_2O_2 + \text{4 – Aminoantipyrine + ADPS} \xrightarrow[Mg^{++}]{\text{Glycerol kinase}} \text{Red quininone} + 4\ H_2O_2$$

GPO = Glycerol-3-Phosphate oxidase

ADPS = N-Ethyl-N-sulfopropyl-n-methoxyaniline

Reagents Composition

Reagent 1:

Contents	Initial Concentration of Solution
Pipes buffer, pH 7.50 ADPS	50mmol/L
ADPS	1mmol/L
Magnesium salt	15mmol/L

Reagent 2:

Contents	Initial Concentration of Solution
Lipoprotein lipase	$\geq$1100 U/L
Glycerol kinase	$\geq$ 800 U/L
Glycerol-3-phosphate oxidase	$\geq$ 5000 U/L
Peroxidase	$\geq$ 350 U/L
4-aminoantipyrine	0.7 mmol/L
ATP	0.3 mmol/L

Standard

Glycerol (Triglycerides equivalent) 200 mg/dL

Precaution

The reagent 1 and the standard contain 0.1 % sodium azide.

Stability of Reagents

When stored at 2 – 8^{o}C and protected from light, the reagents are stable until the expiry date stated on the label.

Preparation and stability of working reagent

Dissolve the reagent 2 in the suitable volume of reagent 1.

Stability: 5 days at 20 – 25^{o} C and 6 weeks at 2- 8^{o} C

Samples

Serum / Heparin plasma

Procedure

Wave length : 546 nm (520 – 570)

Temperature : 37^{o}C

Cuvette : 1 cm light path

Read against reagent blank.

	Blank	**Standard**	**Sample**
Working Reagent	1 ml	1 ml	1 ml
Distilled water	10µl	_	_
Standard	_	10µl	_
Sample	_	_	10µl

Mix and read the optical density (OD) after 5 minute incubation at 37^{o}C. The final colour is stable for at least 30 minutes.

Calculation

$$\frac{\text{OD Sample}}{\text{OD Standard}} \times \text{concentration of standard (200mg/dl)}$$

References

Buccolo and David (1973); Werner *et al*. (1981); Annoni *et al*. (1982)

(III). HDL CHOLESTEROL

Precipitation method, Phosphotungstate magnesim acetate reagent

Clinical Significance

Lipoproteins are the proteins which mainly transport lipid in blood stream. They are (HDL) High density lipoproteins, (LDL) Low density lipo proteins, (VLDL) Very low density lipoproteins and chylomicrons. LDL carries cholesterol to the peripheral tissues where it can be deposited and increase the risk of atherosclerotic heart and peripheral vascular disease.Hence high levels of LDL are atherogenic. HDL transports cholesterol from peripheral tissues to the liver and then for excretion, hence HDL has a protective effect. Hence the determination of serum HDL cholesterol is a useful tool in identifying patients at risk of developing coronary heart disease.

Principle

The chylomicrons, very low density lipoproteins (VLDL) AND Low Density Lipoproteins (LDL) of serum are precipitated by phosphotungstic acid and magnesium ions.

After centrifugation, High density lipoproteins (HDL) are in the supernatant. HDL content of supernatant is measured by an enzymatic method.

Reagent composition

HDL Cholesterol reagent	**4 x 25 mL**
Phosphotungstate	14 mmol/L
Magnesium chloride	1 mmol/L
Preservative	
HDL Cholesterol standard	**1 x 5 mL**
HDL Cholesterol concentration	50 mg/dL

Sample

Serum, plasma (free of haemolysis)

General system parameter

Mode of reaction	End point
Slope of reaction	Increasing
Wave length I	505 nm (500–532 nm)
Wave length II	630 nm
Temperature	37^{o}C
Standard concentration	50 mg/dL
Blank	Cholesterol reagent
Linearity	125 mg/dL
Incubation time	5 min
Sample volume	50 µL
Reagent volume (Cholesterol)	1000 µL
Cuvette	1 cm light path

Laboratory procedure

1. Precipitation

Sample	300 µL
HDL Reagent	300 µL

Mix well; allow standing for 10 minutes at room temperature, mix again and centrifuging for 10 minutes at 4000 rpm.

After centrifugation separate the clear supernatant from the precipitate within 1 hr and determine the HDL cholesterol concentration using the cholesterol reagent.

2. HDL Cholesterol determination

	Blank	**Standard**	**Sample**
Cholesterol reagent	1000 µL	1000 µL	1000 µL
Standard (HDL)	_	50 µL	_
HDL Supernatent	_	_	50µL

Mix and incubate for 5 minutes at 37^{o}C. Measure the absorbance of the standard and sample against the reagent blank.

Calculation

$$\text{HDL Cholesterol concentration in mg/dL} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times N \times 2$$

Where, 2 = dilution factor of the sample

N = Standard concentration (50 mg/ dL)

$$\text{LDL cholesterol} = (\text{Total Cholesterol}) - (\text{HDL cholesterol}) \times \left(\frac{\text{Triglycerides}}{5}\right)$$

References

Gordon *et al*. (1977); Friedewald *et al.* (1972)

(IV). ESTIMATION OF HAEMOGLOBIN

Cyanmethaemoglobin method (NIN, 1983)

The Hb (oxyhaemoglobin, methemoglobin, carboxy haemoglobin) is cinverted to cyanmethaemoglobin according to the following reaction.

$$\text{Hb} \xrightarrow{K_3Fe(CN)_6} \text{Metemoglobin}$$

$$\text{Methemoglobin} \longrightarrow \text{Cyanmethemoglobin}$$

The absorbance of cyanmethmoglobin is proportional to the Hb concentration.

REAGENT

Drabkin's Solution: Dissolve 0.05 g of KCN, 0.20 g of potassium ferricyanide and 1.0 g of sodium bicarbonate in 1 litre of distilled water.

PROCEDURE

20µl of blood is transferred with the help of a Hb pipette into a test tube containing 5 ml of Drabkins solution. Mixed thoroughly and reading taken in a photo electric colorimeter at 546 nm. Optical density of standard haemoglobin solution was also measured using a colorimeter. Hb content of the sample was found out by the formula

$$\text{Hb (gm/dl)} = \frac{\text{Optical density of sample}}{\text{Optical density of standard}} \times N \times 0.251$$

Where N = Concentration of the standard haemoglobin = 60 mg/dl

Appendix – XII

STATISTICAL PROCEDURES USED IN DATA ANALYSIS

Student's t-test for comparing the means

The significance of difference between the observed mean values for various parameters with their standards was examined using Student's t-test.

$t_{(0.05)} = (X-\mu o)/(\sigma/\sqrt{n})$ where,

X – Mean value of the parameter over 'n' number of observations

μ - Standard value

σ – Standard Deviation for the 'n' values

Correlation analysis

Correlation coefficient between x and y = $r_{xy} = \frac{Cov_{xy}}{\sqrt{V_x \times V_y}}$

Cov_{xy} – Covariance between x and y

Vx – Variance of character x

Vy – Variance of character y

Significance of correlation was tested by comparing the obtained values with r values given by Olds (1938).

Regression analysis

From the variance and covariance analysis, simple regression coefficient (b) was worked out with the help of the following formula

$b(x_2/ x_1)$ = (Sum of products of x_2 with x_1)/ (Sum of squares of x_1)

Regression coefficient is tested by 't' test, t = b / S.E. (b)