INTRODUCTION

Obesity is defined as a condition of abnormal or excessive fat accumulation in adipose tissue to the extent that health may be impaired (Garrow 1988). It is now considered as a new world syndrome.

Generally, weight gain and fat storage in human body have been considered as signs of health and prosperity. However with the increase in awareness regarding unhealthy weight gain in the people, obesity is now regarded as a threat to the human health. Globesity, an escalating global epidemic of overweight and obesity, is now so common that it is considered as one of the most significant contributors to ill health replacing the more traditional public health concerns like undernutrition and infectious diseases.

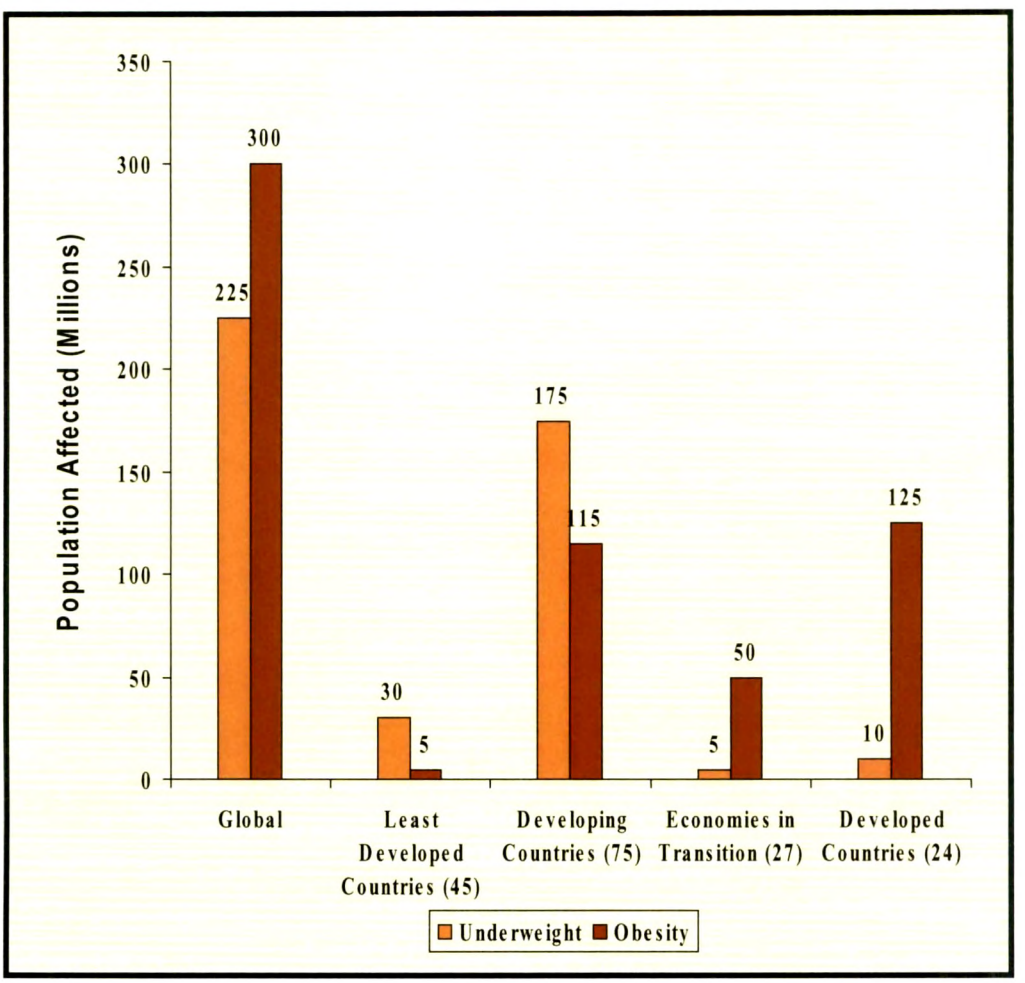
At the other end of the malnutrition scale, obesity is today's one of the most blatantly visible but neglected public health problem. Ironically, co-existing with undernutrition, globesity is spreading in many parts of the world. In recent times obesity is perceived as a first wave of a defined cluster of several Non-Communicable Diseases (NCD) both in developed and developing countries. Obesity is a complex condition with serious social and psychological dimensions affecting virtually all age and socio-economic groups and threatens to affect both developed and developing countries.

In 1995, there were an estimated 200 million obese adults worldwide and 18 million under five children classified as overweight. As of now, the number of obese adults has increased to over 300 million. Contrary to conventional knowledge the obesity epidemic is not restricted to only developed countries but has also spread in developing countries. According to World Health Organisation (WHO 2000) estimate, over 115 million people suffer from obesity (Figure 1.1).

Globesity, a swelling global tidal wave of obesity and Diet Related Non-Communicable Diseases (DNCDs), threatens to envelop us as globalisation

FIGURE 1.1

ADULT POPULATION AFFECTED BY UNDERWEIGHT AND OBESITY BY LEVEL OF DEVELOPMENT



changes the nature of the world's nutrition. Yet another form of malnutrition - development driven obesity is emerging among all age and socio-economic groups especially in countries caught up in the swiftest societal transition. As a result DNCDs such as diabetes, cardiovascular disease, hypertension, stroke and cancer which were previously regarded as 'rich men's diseases', are now escalating in developing countries also, super imposed on precarious health systems already buckling under the double weight of communicable and other non-communicable diseases.

The trends in obesity are not restricted to any one region, country or ethnic group. The highest levels of obesity in middle and lower income countries occur in the Middle East, Western Pacific and Latin America. Though less common in Asia, there is evidence that its prevalence is increasing at an alarming rate throughout the life cycle. The problem appears to be increasing rapidly in children as obesity in school children is already approaching 10% not only in industrialised nations but also in industrialising nations including India (Yadav 2002). The increasing prevalence of obesity in population and particularly among children is an early indicator of the global epidemic of health burden due to NCDs in developing societies.

OBESITY – ETIOLOGY AND RISK FACTORS

The specific cause of obesity is still not known today. The two potentially premorbid effects that begin to operate during adolescence are changes in the quantity and location of fat (Mueller 1982). In girls, body fat changes from 17% of body mass to 24% over the period of adolescence (Cheek 1968). In contrast to girls, boys lose body fat but the central deposition of body fat increases almost five fold whereas this increase in females is only approximately three fold (Goran et al 1995). Maternal obesity increases transfer of nutrients across placenta inducing permanent changes in appetite, neuro-endocrine functioning and energy metabolism (Whitaker and Dietz 1998). Rolls et al (2000) introduced the concept that as children grow older they become less responsive to internal hunger and satiety and are more reactive to environmental stimuli. According to Catherine et

al (2001), children who inherit a paternal polymorphism associated with altered expression of the insulin genes have increased risk of developing early onset obesity. Lawrence (2002) reported that researchers have discovered a hormone (Gastric Inhibitory Polypeptide) secreted in small intestine playing an important role in determining whether dietary fat is stored in adipose tissue or consumed as fuel. A variety of factors affect the deposition of body fat. As with adult onset obesity, childhood obesity has multiple causes centering on an imbalance between energy input of calories from food and energy output (calories expanded in the basal metabolic and physical activity). Many complex and diverse factors give rise to a positive energy balance. The current relative adiposity is a product of the interaction between genetic predisposition with regard to the storage of body fat and environment (low physical activity, high availability of calorie-dense foods) that is increasingly permissive to the expression of that genetic tendency. The recent epidemiological trends in obesity indicate that the primary cause of global obesity problem lies in environmental and behavioural changes. This rapid increase in obesity rate has occurred in too short a time for them to bring significant genetic changes within populations. The global obesity problem in children can be viewed as a consequence of massive social, economic and cultural problems now faced by the developing countries. The increasing proportion of fat and energy dense foods in the diet and the rise in sedentary behaviour strongly influence the energy balance equation. These are major modifiable factors through which many of the external forces leading to weight gain act.

Table 1.1 summarises food environment factors hypothesised to increase energy intake and physical activity environment factors hypothesised to decrease energy expenditure.

McNutt et al (1997) reported higher prevalence of obesity among girls (9-10 years) consuming fast foods four times or more a week than those who did not. This was due to consumption of additional 185-260 kcal per day. Ludwig et al (1999 and 2002) reported that the consumption of meals with high Glycemic Index (GI) foods induces a sequence of hormonal events stimulating hunger and

TABLE 1.1

ENVIRONMENTAL FACTORS AFFECTING ENERGY BALANCE

Environmental Factors	
Food • Portion size • High fat, high energy density • High glycemic index • Availability of soft drinks • Sugar • High accessibility • Low cost • Great taste • Variety • Advertising, fast/convenience	**Physical activity** • Declining hold for physical activity in the work place, computerisation, automation • No requirement of physical activity in school, reduction in free play • Physical activity 'unfriendly' community design • 'Drive through' convenience • Automobile based transport system • Elevators/Escalators • Inaccessible/inconvenient stair access • Remote controls • TV/computer games / Internet, sedentary entertainment • Household appliances, labour saving devices

Source : Peters 2002

cause overeating in adolescents. His study also showed that the risk of developing obesity in school children increases by 60% for every additional daily serving of sugar sweetened drinks. Maggie et al (2002) found that children whose parents scored highest on either dietary restraint (individual's conscious efforts to restrict food intake) or disinhibition (impulsive eating) had greater increase in body fat.

Epstein (1995) suggested that obese children are more sedentary than their non-obese peers and chose to be sedentary when given the option of being active or sedentary. Grieger (2000) reported that inactivity plays a major role in obesity in children as they spend considerable time viewing Television (TV), playing video games and using computer. TV viewing is associated with the onset of obesity, increases in inactivity levels and may possibly influence diet (Gortmaker, Dietz and Chung 1990). Robinson (2001) reported that dance intervention could result in reduction in Body Mass Index (BMI) and improve physical fitness among girls. According to Jonathan et al (2000) reduction in TV viewing significantly decreased the measurements of obesity viz. BMI, Waist to Hip Ratio (WHR), Skin Fold Thickness (SFT) and Waist Circumference (WC) in kids.

The role of genetic factors in weight gain and the discovery of leptin and the obesity gene are the current topics of research. Leptin, the hormone product of this gene, is an important satiety factor secreted by the adipose tissue in humans. Various studies have identified a region on human chromosome 2 that accounts for variation in serum leptin concentration and fat mass in population (Ruhl and Everhart 2001).

Psychosocial influences on childhood obesity include personality, coping styles, perceived barriers, interpersonal skills, parental psychological functioning and body image (Dorman et al 1995). Interventions between genes and an environment characterised by energy imbalance due to sedentary lifestyles and ready access to an abundance of food, results in obesity (Sherwood 2000).

While the basic cause of overweight and obesity is simply an imbalance between energy intake and energy expenditure it is in practice a complex condition arising from a multiplicity of factors viz. genetic, biological, environmental and behavioural factors. Indeed, obesity may be aptly described as a genetic misfortune, a behavioural gamble in a tempting environment (Florentino 2002). A downward spiral of development and consequences of obesity is presented in Figure 1.2.

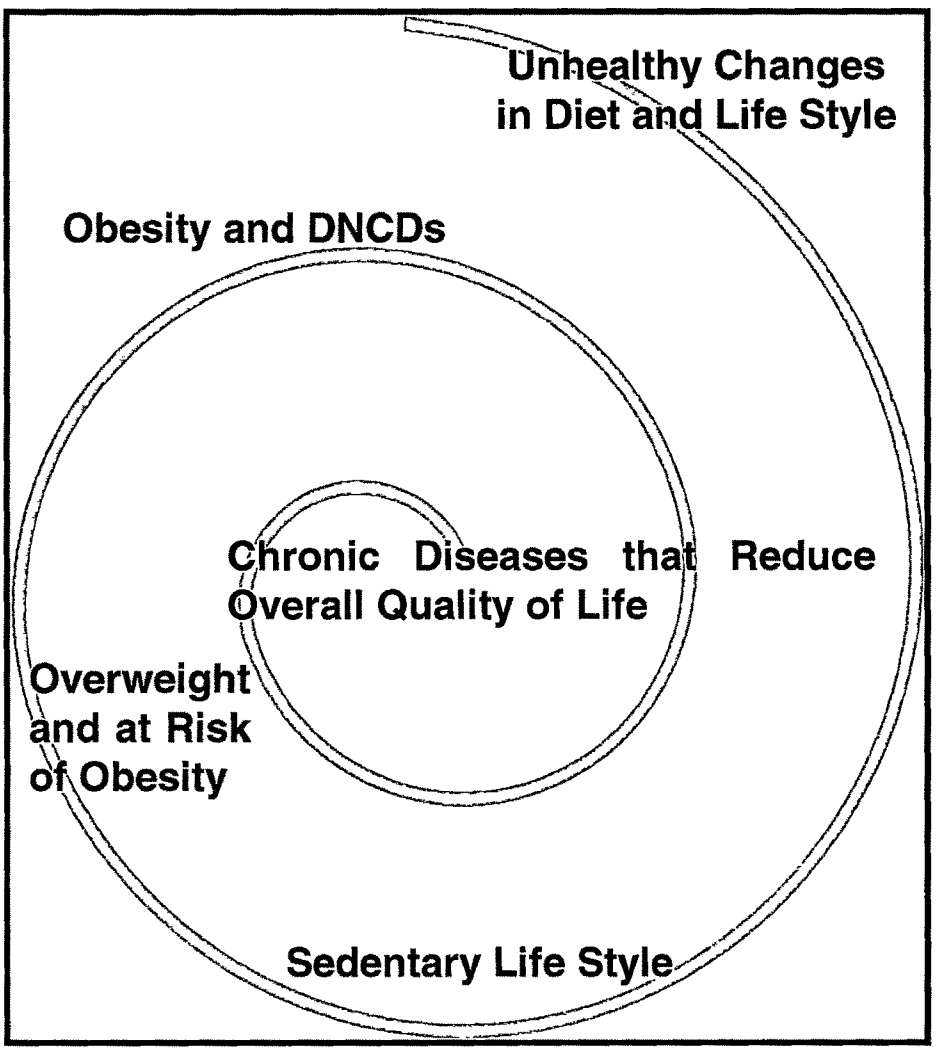
CONCERNS RELATED TO CHILDHOOD OBESITY

Understanding the trends in childhood obesity is necessary as obesity in childhood has many adverse effects on health both in childhood and adulthood. Childhood obesity is not a disease as there are few known physical health risks among children who are obese. The primary concern for childhood obesity is the subsequent obesity during adulthood, leading to health problems. Children who are obese are at somewhat increased risk of becoming obese adults; that is the relative weight and skin fold thickness tend to 'track' overtime. The probability that obesity will persist into adulthood is 50% if the child is more than six years of age, and 70%-80% for an obese adolescent. The presence of obesity in at least one parent increases the risk of persistence in children at every age.

Sugrimori et al (1999) studied the temporal causes of obesity by tracking 479 Japanese children over 12 years. Among children who were obese at 17 years, most could be tracked from primary school. The earlier the child was detected to be obese, the greater the BMI at 17 years of age. The BMI at adolescence was noted to be an important predictor of adult obesity. Increasingly, obesity is now recognised as a chronic condition, the root of many other chronic diseases and just should not be dismissed as a weakness of self-discipline and gluttony. As a result of the global obesity epidemic, many chronic diseases are now appearing in childhood itself rather than adulthood. Obesity results in physical and psychological consequences to the affected individual. It also poses a significant economic burden to the society.

FIGURE 1.2

DOWNWARD SPIRAL OF DEVELOPMENT OF OBESITY AND ITS CONSEQUENCES



Must et al (1992) concluded that overweight in adolescence increases the mortality from various Chronic Degenerative Diseases (CDD) such as coronary heart disease, stroke, colorectal cancer and morbidities such as gout and arthritis.

The Bogalusa heart study among obese individuals between five and twenty four years of age showed significant clustering of three risk factors for cardiovascular disease, high systolic blood pressure, high fasting levels of insulin and high ratios of Low Density Lipoprotein Cholesterol (LDL-C) to High Density Lipoprotein Cholesterol (HDL-C). Dyslipidemia, hypertension and insulin resistance are frequently seen in obese children. The incidence of Non Insulin Dependent Diabetes Mellitus (NIDDM) among obese adolescents increases by 10 times. They have higher fasting blood glucose (FBS) and insulin levels and abnormal glucose test results (Webber et al 1991).

Bavdekar et al (1999) have shown that total cholesterol and LDL-C levels are high in children of low birth weight but with high fat mass at 8 years. The central adiposity is associated with increased free fatty acids due to lipolysis of visceral fat and increased Very Low Density Lipoprotein Cholesterol (VLDL-C) and LDL-C synthesis due to hyperinsulinemia.

Various studies have shown an association between severe childhood obesity and increased incidence of acute respiratory infections and sleep apnoeas. The obese children are at increased risk of orthopedic problems such as tibial torsion, bowl bowed legs and slipped capital femoral epiphysis. They are also prone to skin disorders such as heart rash, intertrigo, monoleal dermatitis and Acanthosis nigercans (WHO 2000).

Obesity can have very significant psychological consequences. Stafferi et al (1967) reported children only six years of age who labeled silhouettes of an overweight child as lazy, dirty, stupid and ugly. Bruche (1975) described the psychological consequences of obesity in children. According to him fat in excess in children is a sad thing. They are bashful and ashamed of their shapeless

figures yet unable to conceal them. They attract attention wherever they go. Obesity is a serious handicap in the social life of a child more so for a teenager. Loke (2002) discussed the detrimental consequences of poor self-esteem, which includes significantly increased rates of sadness, loneliness and nervousness in obese adolescence compared to non-obese children. These obese children are more likely to engage in high-risk behaviours such as smoking and alcohol consumption. He also pointed out that for obese children, adolescence and adults, there is the burden of direct medical cost covering the cost of prevention, diagnosis and treatment. There are also indirect costs that refer to the value of low output through the cessation of productivity, caused by morbidity and mortality. Wang (2000) concluded that among all hospital discharges in youth from six to seventeen years of age, the proportion of discharge with obesity associated disease had increased dramatically in the past twenty years in US. These findings reflect the impact of an increased prevalence and severity of obesity. The obesity associated annual hospital cost had increased more than three fold.

Obesity is leading cause of pediatric hypertension and a known risk factor for adult obesity. Thus obesity causes a great loss of quality of life and suffering both to the patients and to their families.

PREVALENCE OF OBESITY IN CHILDREN

Global Scenario

Over the past century most nutrition research and policies concerning the developing world was focused and restricted to poverty and undernutrition. However, now there is a significant swing towards research on overweight and obesity in these societies in all age groups. According to WHO, the global prevalence of overweight and obesity has reached epidemic proportion. Many studies have documented the increase in overweight among adults. Recently, De Onis et al (2000) and Matoate et al (2000) examined obesity in preschool children from developing countries. There are several reports discussing the rapid increase in childhood obesity in higher income countries. Apart from this

large global prevalence, two other features make this picture even more alarming, rapidly increasing prevalence in the last decade and increasing prevalence of overweight and obesity among children.

In the US since the 1960s large nationally representative surveys have assessed the prevalence of obesity in children. The National Health Examination Surveys (NHES) I, II and III have observed the prevalence of obesity to be 25%-30% percent. The surveys found that the Hispanics, Native Americans and Black population were more affected. The estimations from Canada showed that childhood obesity ranged from 7%-43%. The condition is more common among Native Canadians. A national survey in Britain in 1974 showed that 7.3% of the children and adolescents between 7-16 years of age were obese. In Japan, between 1974 and 1993, the prevalence of obese school children increased from 5%-10%. Kromeyear and Hauschild et al (1999) reported the increase in prevalence of obesity in German school children during 1975-1995 from 5%-8% in boys and from 4%-10% in girls. In Thailand, it rose from 12.7% in 1991 to 15.6% in 1993. In Saudi Arabia it was 15.8% among males from 6-18 years of age (WHO 2000). Table 1.2 presents the global scenario of overweight and obesity in children.

Indian Scenario

The developing countries in Southeast Asia are in a state of socio-economic transition in which undernutrition co-exists with overnutrition. In some countries undernutrition predominates among children, while in other countries the rising prevalence of obesity among children is of greater concern. Nationally representative data are not available from India. However, school based studies from middle income schools have shown that about 10% of 8-16 years old children are obese. In a study of school children from 9-12 years of age, prevalence of obesity was 5.6% (Yadav 2002). Jayshree (2001) reported the prevalence of obesity in preadolescent children as 16.3% and 2.8% in adolescents. A study carried out by Singh (2000) on affluent school children (10-16 years) of Delhi showed the prevalence of obesity as 13.4%. Table 1.3 summarises the available prevalence data on school children of India.

TABLE 1.2

PREVALENCE OF CHILDHOOD OBESITY

GLOBAL SCENARIO

Country	Year	Age (y)	Prevalence (%)
US	1980	6-11 12–17	27.1 21.9
Canada	1980	9-15	7-43
England	1974	7-16	7.3
Japan	1993	6-14	10
Thailand	1993	6-13	15.6
Saudi Arabia	1996	6-18	15.8
India	1995 1998	8-16 10	10 5.6

Source : Yadav (2002)

TABLE 1.3

PREVALENCE OF OVERWEIGHT AND OBESITY

INDIAN SCENARIO

Author	Year	Age (y) / Group	Place	Prevalence (%)				
Gupta et al	1990	05-15	Delhi	7.6% obesity				
Singh	2000	10-16	Delhi	13.4% obesity				
S. Jayshree	2001	Children	Dharwad	Overweight 16.3% children, 2.8% adolescents				
De Onis et al	2001	Young boys	West Bengal	4.2% overweight				
Kapil et al	2002	10-16	Delhi	7.4% overall obesity 8% - Boys, 6% - Girls				
Vijayalakshmi et al	2003	13-18	Hyderabad	Overnutrition (%)	Boys		Girls	
					LIG	HIG	LIG	HIG
				Overweight	0.4	17.5	1.29	16.0
				Obesity	-	11.9	-	5.9

At regional level, under the guidance of Prof. U. V. Mani, at the Department of Foods and Nutrition, M. S. University of Baroda, Vadodara, a series of studies in the area of adult obesity were undertaken (Table 1.4). The magnitude of the problem of overnutrition in adult population is a matter of concern. However, few efforts have been made to map the prevalence of overweight and obesity among older children and adolescence of Gujarat, India. Most recent studies carried out to map the prevalence in school children of urban Vadodara (Table 1.5) have shown an increasing prevalence of overweight and obesity.

DEFINING OVERWEIGHT AND OBESITY IN CHILDREN

Anthropometry is one of the most basic tool for assessing nutritional status, be it undernutrition or overnutrition. There are a number of methods available to measure body fatness and body thinness. Some of the most commonly used techniques for their accurate estimations are under water weighing, Dual energy X Ray Absorptiometry (DXA), total body water, total body electric conductivity, total body potassium and computed tomography. The use of most of these methods is restricted to research setting only on account of their complexity and cost. The direct estimation of fat and free fat mass is very challenging, more so because it is influenced by age and state of maturation. Out of these only a few techniques are useful for children. The most frequently used tool in public health evaluations and clinical screening or school settings are anthropometric based measurements such as skin fold thickness, circumference measurements or various height and weight based indices such as weight for height, BMI and Rohrer Index.

Skin fold thickness is a more precise measure of adiposity. However, the comparability across cross section surveys is less consistent and standard data are not internationally available for children and adolescents. The BMI measured as weight (kg)/height (m^2), has become the most desirable index for diagnosis of obesity. The BMI curves have been generated for children for a number of countries such as US, Britain and Sweden. International Obesity Task Force

TABLE 1.4

PREVALENCE OF OVERWEIGHT AND OBESITY IN ADULTS

DEPARTMENTAL STUDIES

Author	Year	Setting	Age	Sample Size	Prevalence (%)	
					Ow	Ob
Khandakar*	1999	Urban Vadodara	18-24 y females	229	22.7	23.1
Bhat*	1999	Urban Vadodara	30-50 y males	125	31.2	5.6
Fernandez*	1999	Urban Vadodará	30-50 y females	125	30.0	8.8
Patel*	2000	Urban Vadodara	50-60 y males & females	200	44.0	8.5
Tiwari*	2002	Urban Vadodara (Hostel girls)	18-22 y females	700	8.6	2.9
Khan*	2002	Urban Vadodara (MSU staff)	≥ 18 y males & females	530	14.2	3.4
Desai**	2003	Urban Vadodara (Industrial)	20-60 y males & females	1025	33.0	8.0

Ow – Overweiight

Ob – Obese

* MSc thesis, Department of Foods & Nutrition, Vadodara

** PhD thesis, Department of Foods & Nutrition, Vadodara

TABLE 1.5

PREVALENCE OF OVERWEIGHT AND OBESITY IN SCHOOL CHILDREN OF URBAN VADODARA

Author	Year	Age (y)	Prevalence (%) (Cole et al standards)
Parikh*	2002	12-17	Overweight – 7.0 Obese – 0.7
Akolkar*	2003	6-12	Overweight – 14.4 Obese – 5.9
Venugopal*	2004	11-15	Overweight – 14.0 Obese – 2.5
Mani et al	2004	10-18	Overweight – 13.4 Obese – 2.6

* MSc thesis, Department of Foods & Nutrition, Vadodara

(IOTF) have recommended Cole et al Standards (2000) which are based on BMI extrapolated for age and gender specific cut off points to classify overweight and obesity in children (2-18 years).

The Evaluation of obesity in children is invaluable since it offers paramount prospects for preventing its progress with its associated morbidities into adulthood. However defining obesity or overweight for children and adolescents is difficult for want of consistency and agreement between different methods used for their classification. The height and weight measures can be obtained with a reasonable accuracy in a variety of settings including field studies, clinical practice and research. Hence weight status based on height and weight is commonly used for classification. They are one of the most practical tools for assessing the nutritional status on account of their simplicity and low cost. Of these methods, BMI is most widely used and recommended for classifying overweight and obesity.

The studies carried out on indicators of obesity to be used for children suggested that the age and sex specific BMI cut off values proposed by Cole et al (2000) and Must et al (1991) can be used for the prevalence of obesity in children (Abrantes et al 2002). Mei et al (2002) concluded that the performance of BMI for age is better than Rohrer index {wt (kg)/ht (cm^3)} for age in predicting underweight and overweight. Khadgwat et al (1998) suggested that Agarwal charts based on Indian affluent school children are better representative of the growth of normal Indian children than Indian Council of Medical Research (ICMR) or National Council for Health Statistics (NCHS) standards.

WC is now accepted as one of the practical measures of adipose tissue distribution (Wang et al 2003). He highlighted that the WC measurements are increasingly being promoted as a part of clinical obesity evaluation. Dasgupta and Hazra (1999) concluded that WC is simple to assess and can be used as an independent measurement to identify those at risk from either increased body weight or central fat distribution or both. Clasey et al (1999) and Lean et al (1996) found that WC measured at the narrowest point of the torso is a strong predictor

of total adipose tissue and visceral adipose tissue (VAT) measured with computed tomography. The cut off values for the indicators of obesity are listed in Table 1.6.

Fu et al (2003) concluded that IOTF recommended BMI cut off values had lower sensitivity and may underestimate the local prevalence of childhood obesity. For screening purpose, population specific measures rather than international cut off values should be used. Gei et al (2001) concluded that in prepubescent children, height to weight indices such as BMI or Ponderal Index (PI) could predict cardiovascular risk factors better than SFT. The BMI may be superior to PI as the association between BMI and Cardiovascular Disease (CVD) is less affected by gender.

WHO experts have recommended that thinness as well as obesity should be evaluated by body ponderosity indices particularly BMI and SFT. It has been recommended that 85th percentile of BMI should be considered as cut off point for overweight and greater than 95th percentile for defining obesity for its association with height and other morbidities in children. Daniel (2000) demonstrated that WC was one of the simple measures of fat distribution as it was least affected by gender, race and overall adiposity. Moreover WC is easy to determine and is a useful measure of fat distribution for children and adolescents.

From the view of public health importance the trends in childhood obesity should be closely monitored. Trends are however difficult to quantify or to compare internationally as a wide variety of definitions of childhood obesity are in use and there are no commonly accepted standards. The ideal definition based on percent body fat is impracticable for epidemiological use. Clearly a cut off point reflected to age and sex is needed to define childhood obesity, which is based on adult cut off points for overweight and obesity (Cole et al 2000).

From the current literature it is clear that the global epidemic of overweight and obesity is at our doorstep. The emerging problem of overweight and obesity in children is a matter of growing concern. Several reports have shown the

TABLE 1.6

CUT OFF VALUES FOR THE INDICATORS OF OBESITY

Index	Obesity	Severe Obesity	Relative Information
Mean weight for height	> 120%	> 140%	Actual weight is 20% more above the mean weight for children of this height.
Weight for height	> 85 percentile	> 95 percentile	Readily available reference charts. Easy to use but doesn't differentiate between body mass and fat.
Skin fold thickness over triceps	> 85 Percentile	> 95 percentile	Direct measurement of subcutaneous fat. Accurate measurement of obesity but more intra observer variability.
Body Mass Index (kg/m^2)	≥ 85 percentile	≥ 95 percentile	Percentiles are age and gender specific. Better correlates excess weight to fat in younger children and adolescents.
Ponderal index (kg/m^3)	> 85 percentile	> 95 percentile	Percentiles are age and gender specific. Better correlates excess weight to fat in older children.

Source : Moran 2001

increasing the increasing rates of obesity in developed countries whereas the magnitude of the problem in India and regional context remains relatively unknown. The foremost is the paucity of national and regional prevalence and epidemiological data on overweight and obesity in children and adolescents.

Therefore the present study was planned to find the magnitude and trends of overweight and obesity amongst school children of urban Vadodara in western part of Gujarat, India and to identify the risk factors associated with it.

The specific objectives of the study were

- To assess the prevalence of overweight and obesity in school children (12-17 years) of urban Vadodara
- To study the correlation between energy intake and energy expenditure in children
- To investigate the effect of lifestyle factors including dietary practices and activity pattern on the prevalence of obesity
- To assess the metabolic aberrations with respect to lipid profile in overweight and obese children
- To develop age and sex specific BMI percentile curves