PREVALENCE AND DETERMINANTS OF OBESITY AMONG ADOLESCENTS IN THE KINGDOM OF BAHRAIN

A thesis

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This work is dedicated to the souls of my parents,

Mohammed and Mooza, may they rest in peace.

ABSTRACT

Over the last 30 years Bahrain has witnessed remarkable economic growth and social development. This has resulted in tremendous changes in the dietary habits and lifestyle of the population and consequently increased levels of obesity. A cross-sectional study involving a representative sample of 506 Bahraini adolescents (249 males and 257 females), aged 12 to 17 years, was carried out to estimate the prevalence of obesity, its contributing factors and relationship to the risk of developing high blood pressure. The sample was selected, using a multi-stage random sampling technique, from intermediate and secondary schools in Bahrain. Data was collected using anthropometric measurements, blood pressure measurement and a self-administered questionnaire. A separate case control study, which included a sample of obese and non-obese adolescents, was carried out to investigate the relationship between adolescents' obesity and the family environment.

Twenty one percent of the male and 35% of the female participants were obese using the WHO criteria for obesity in adolescents. A distinct sexual dimorphism in the accumulation of body fat during adolescence was observed. Thirty two percent of the boys and 60% of the girls had a percentage body fat at or exceeding the high-risk threshold for fatness, according to the currently accepted criteria. Systolic blood pressure, waist circumference and waist-hip ratio were all positively associated with body fatness. Multivariate analysis showed that higher levels of mother's education, frequent snacking and distress eating were all independent factors associated with an increased risk of obesity. Factors associated with a reduced risk of obesity included playing sport outside school, walking or cycling to school and eating meals with the family. Among the family environment variables, parental obesity and history of diabetes; mother's lifestyle variables, namely physical exercise and hours of television viewing, were all found to be independently related to risk of obesity in the Bahraini teenagers. Mother's degree of control over child's eating was strongly and indirectly related to risk of obesity in the adolescents. Breastfeeding, birthweight and availability and accessibility of high calorie foods in the house did not appear to be associated with adolescents' obesity. Eighteen percent of boys and 10% of girls had high blood pressure. BMI, percent body fat and waist circumference were all significantly and positively associated with a risk of having elevated blood pressure. Approximately 30% of the adolescents underestimated their current weight and about 40% thought that their parents/peers would consider them to be leaner than they actually were. More than half of the girls and about one third of the boys expressed discontent with their current body weight.

Lifestyle changes and nutrition transition associated with economic development in Bahrain has increased risk of obesity among adolescents, a characteristic now evident in most countries in the Arab Gulf Region. This study provides an insight into the various determinants of this epidemic and will help to initiate public health strategies to deal with this increasing burden on health in the region.

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Glossary

AFA	Arm fat area
AMA	Arm muscle area
AMC	Arm muscle circumference
BIA	Bioelectric impedance analysis
BMI	Body mass Index
BP	Blood pressure
CDC	Center of Disease Control
CHD	Coronary heart disease
CI	Confidence interval
CT	Computerised tomography
CVD	Cardiovascular diseases
DBP	Diastolic blood pressure
DEXA	Dual energy X-ray absorptiometry
HDL-C	High density lipoprotein-cholesterol
IAF	Intra-abdominal fat
IOTF	International Obesity Task Force
LDL-C	Low density lipoprotein-cholesterol
MRI	Magnetic resonance imaging
MUAC	Mid upper arm circumference
NHANES	National Health And Nutrition Examination Survey
NIDDM	Non-insulin dependent diabetes mellitus

Normal wt	Normal weight
OR	Odds ratio
Over wt	Overweight
PA	Physical activity
PI	Principal investigator
SBP	Systolic blood pressure
SES	Socio-economic status
SSKF	Subscapular skinfold
STR	Subscapular to triceps ratio
TG	Triglycerides
TSKF	Triceps skinfold
Under wt	Under weight
WC	Waist circumference
WHO	World Health Organisation
WHR	Waist to hip circumference ratio

CHAPTER I: INTRODUCTION

Obesity is becoming a major public health problem, affecting people of all ages and an increasing number of countries worldwide. The health consequences of obesity are well documented. Excessive fatness is associated with many chronic diseases such as coronary heart disease, hypertension, diabetes and some forms of cancer (WHO, 2000). Although most of these complications are associated with adult obesity, significant morbidities, including a variety of physical, social and psychological problems have been observed in obese children. Dyslipidemia, hyperinsulinemia, impaired glucose tolerance and elevated blood pressure have all been shown to be associated with childhood and adolescent obesity (Freedman *et al.*, 1999a). There is also evidence that, as in adults, the pattern of body fat distribution during adolescence, particularly intra-abdominal fat accumulation, may be important in increasing the risk of these metabolic disturbances (Goran & Gower, 1999). Furthermore, childhood obesity, especially in adolescence, predisposes to adult obesity, and the likelihood of obesity being continued into adulthood is greatest when both parents are obese (Whitaker *et al.*, 1997).

In children and adolescents, assessment of obesity is problematic. Unlike the situation in adults where a universally applicable system of classifying obesity and overweight is available, there has been little agreement on either the method or the cut-offs to be used in defining obesity in children and adolescents. This is largely due to the physiological changes associated with growth and maturation, which complicate assessment of body composition at this age. The World Health Organisation (WHO) Expert Committee has recommended the use of both Body Mass Index (BMI) and skinfold thickness as the best indicators for the assessment of obesity in adolescents. Obesity is diagnosed when the body mass index exceeds the 85th percentile for age and when both the triceps and subscapular skinfolds are equal to, or greater than, the 90th percentile for age (WHO, 1995).

The prevalence of obesity among the child and adult populations in Western societies is high and appears to be increasing at alarming rates. Obesity may be relatively uncommon in some Asian and African countries but it is more prevalent in urban than rural communities and is steadily rising in many developing countries, particularly those undergoing rapid economic transition (WHO, 2000). In Bahrain, for example, available data indicate that the prevalence of obesity in adults is high, especially in females (Al-Mannai *et al.*, 1996). A population-based study showed that 56% of men and 79.6% of women in Bahrain were overweight or obese (BMI $\geq$25 kg/m^2) (Musaiger *et al.*, 2000b). Studies on the occurrence of obesity among children and adolescents in Bahrain are scarce. An early study conducted on 121 Bahraini girls between the ages of 7-18 years revealed that 19% of the girls were obese ($\geq$85th percentile of skinfold thicknesses) (Blair & Gregory, 1985). A subsequent study in which a BMI cut-off of 25 kg/m^2 was used to determine obesity, reported that 15.6% of the male and 17.4% of the female secondary school students in Bahrain were obese or overweight (Musaiger *et al.*, 1993). However, overweight/obesity in adolescents cannot be defined on the basis of a single BMI cut-off for all ages as used for adults, since it is known that during adolescence BMI varies considerably with age. Thus it is possible that these estimates reported by Musaiger *et al.* (1993) are inaccurate and may not therefore reflect the magnitude of the obesity problem in Bahraini adolescents.

The aetiology of obesity is to a large degree uncertain, but both genetic and environmental factors appear to be important. Studies on the physiology and genetics of human obesity have provided evidence that body weight is regulated, and some of the genes involved in this regulatory system have been identified. Family studies and studies on twins and adoptees have demonstrated that 30% to 50% of the inter-individual difference in adiposity is due to genetic factors (Bouchard *et al.*, 1998). The current surge in the global prevalence of obesity may also reflect socio-cultural and environmental changes that promote overeating and sedentary lifestyles (Prentice & Jebb, 1995). Since the mid 1970s, Bahrain has experienced dramatic economic growth and rapid social development, which are believed to have led to great changes in the food consumption patterns and lifestyle of the population and consequently different trends of diseases and mortality. Cardiovascular diseases are now the major cause of mortality in Bahrain, representing one third of the total deaths (Ministry of Health, 2000). A high prevalence of non-insulin dependent diabetes (NIDDM) has also been documented among the Bahraini adult population (Al-Mahroos & McKeigue, 1998).

Studies indicate that risk of overweight in children and adolescents is strongly linked to low physical activity, increased television viewing and the family environment, including parents' obesity and lifestyle behaviours (Dietz & Gortmaker, 1985; Birch & Davison, 2001). The importance of these determinants and how they interact to produce obesity in children is not clear and no study has attempted to examine adequately the relationship between these multiple categories of factors and obesity among adolescents in Bahrain. Strategies to reduce the risk of obesity and its co-morbidities in adulthood need to be initiated at an earlier age, i.e. during childhood and adolescence (WHO, 1990). This necessitates an understanding of excessive weight gain during this crucial period of growth. The general aim of the present study is to determine the prevalence of obesity among adolescents in Bahrain and to investigate factors associated with its development.

CHAPTER II: BACKGROUND TO THE STUDY

Throughout history man has evolved efficient physiological mechanisms to defend against body weight loss. The ability to conserve surplus energy as adipose tissue in the body fat depots so that it can be utilised in times of need has conferred survival advantages in a harsh environment where food supply can be scarce. Today however, in our modern environment, which provides easy access to calorie dense foods and encourages a sedentary lifestyle, the metabolic consequences of these physiological mechanisms are becoming maladaptive (Rosenbaum & Leibel, 1998). As a result obesity has emerged as a worldwide phenomenon, affecting high as well as middle-income groups and both adults and children alike (WHO, 2000).

2.1 PREVALENCE OF CHILDHOOD AND ADOLESCENT OBESITY

While the global epidemic of overweight and obesity is well documented in the adult population, estimates of the prevalence and secular trends of this problem in children and adolescents are difficult to make and compare (WHO, 2000). This is largely because of the lack of a well-accepted international definition of obesity and overweight in this age group. Nevertheless, there is evidence that childhood and adolescent obesity is a growing problem in both the developed and developing countries, which parallels that seen in the adult population (Troiano & Flegal, 1998; Chinn & Rona, 2001; de Onis & Blossner, 2000). In the United States for example, data from the National Health & Nutrition Examination Surveys (NHANES) show that approximately 11% of children (aged 6-11 years) and adolescents (aged 12-17 years) were overweight (BMI ≥ 95th percentile) in the 1988-1994 period. An additional 14% had a BMI between the 85th and 95th percentiles and therefore had an increased risk of becoming overweight (Troiano & Flegal, 1998). A study from Japan that has investigated the trends of obesity among 6-14 year old children during the 1974 –1995 period showed that the rates of obesity (≥120% of standard body weight) and that of extreme obesity (≥140% of standard body weight) have doubled from 5% to 10% and from 1% to 2%, respectively (Kotani *et al.*, 1997). The rising trend in childhood and adolescent obesity is not only confined to the industrialised countries; many developing countries are experiencing a similar or even higher rise. Thailand for example, has seen an increase in the prevalence of obesity among school-aged children (6-12 years) from 12.2% in 1991 to 15.6% in 1993 (Mo-suwan *et al.*, 1993). Chu (2001) reported an increase in the prevalence and trends of obesity (but not overweight) among 12 to 15 year old schoolchildren in Taiwan; during the 1980 to 1994 period, rates of obesity increased from 12.4% in boys and 10.1% in girls to 16.4% and 11.1%, respectively. Table 2.1 presents the prevalence of obesity among children and adolescents in selected countries.

Table 2.1. Prevalence of obesity among adolescents in selected countries

Country	Age (years)	Criteria for obesity/overweight	Prevalence	Source
USA	12-17	BMI 85-95th percentile BMI ≥95th percentile	14% 11%	(Troiano & Flegal, 1998)
France	4-17	BMI >90th percentile BMI >97th percentile	11.7% 3.2%	(Rolland-Cachera *et al.*, 1992)
Italy	11-19	BMI ≥85th percentile BMI≥85th percentile plus≥ 90th percentile for TSKF and SSKF	21.3% (boys) 21.5% (girls) 9.8% (boys) 6.3% (girls)	(De Vito *et al.*, 1999)
Japan	6-14	≥120% of standard body weight	10%	(Kotani *et al.*, 1997)
Thailand	6-12	≥120% weight for height	15.6%	(Mo-suwan *et al.*, 1993)
Taiwan	12-15	≥120% weight for height	16.4% (boys) 11.1% (girls)	(Chu, 2001)
Seychelles	15-17	IOTF standard –overweight* IOTF standard –obesity	12.6% 3.8%	(Stettler *et al.*, 2002)

* The International Obesity Task Force (IOTF) standard (Cole *et al.*, 2000)

In view of the fact that different criteria are used by different investigators as evident in the table above, the International Obesity Task Force (IOTF) has recently focused attention to this problem and suggested a useful BMI standard for estimating the prevalence of childhood and adolescent obesity both within and between different countries (Cole *et al.*, 2000). Bellizzi *et al.* (2001) used this standard to quantify and compare the prevalence of overweight among adolescents in some Asian and European countries. The authors included population representative anthropometric data for 15-year-old boys and girls from 4 Asian countries (Taiwan, Japan, Hong Kong and Singapore) and 4 European countries (Italy, Hungary, United Kingdom and the Netherlands). With a few exceptions, the data spanned the period between the late 1980s to the late 1990s. The results indicated that the level of total overweight was highest in Taiwan (30.5% in boys and 21.1% in girls) and Italy (22.8% in boys and 16.3% in girls). The results also confirmed the high prevalence of overweight among adolescents from different Asian countries and revealed marked sex differences, with rates of overweight being much higher among Asian boys than among girls.

2.1.1 Prevalence of obesity in the Arabian Gulf Region

Available data from the Arabian Gulf countries, namely Bahrain, Kuwait, Saudi Arabia, Qatar, United Arab Emirates and Oman, indicate that obesity is a serious and growing problem in this region, especially among women (Al-Mannai *et al.*, 1996; Al-Nuaim *et al.*, 1996a; Al-Hamad, 1999). A population-based study showed that 21% of men and 48.6% of women in Bahrain were obese (BMI≥30) (Musaiger & Al-Roomi, 1997). A study from Saudi Arabia by Al-Nuaim *et al.* (1996a), which included a representative sample of 13,177 subjects aged 15 years and above, reported that the prevalence of overweight (BMI ≥25) among males and females was 29% and 27% and that of obesity (BMI ≥30) was 16% and 24%, respectively.

In children and adolescents, the prevalence of overweight and obesity has also shown a similar increasing trend (Table 2.2). Al-Mousa and Parkash (2000) assessed the prevalence of overweight and obesity in Kuwaiti schoolchildren. Data was collected as part of an on-going national health surveillance programme. The sample included 10,893 children aged 10-13 years and 10,512 adolescents aged 14-17 years. The results showed that the prevalence of overweight and obesity (BMI≥85th percentile of the NHANES reference) among the 10-13 year old boys and girls was 36.8% and 35.9%, respectively. Among the older children, the prevalence was 27.6% in boys and 31.1% in girls. Al-Nuaim *et al.* (1996b) determined the prevalence of overweight and obesity among 9,061 male schoolchildren aged 6-18 years in Saudi Arabia. It was found that 15.8% of boys were obese (≥120% of the expected BMI median of the NCHS/CDC reference) and 11.7% were overweight (110-120%). A study from Oman reported that the prevalence of obesity (≥85th percentile) among 11-18 year-old girls was 12% (Musaiger, 1994a).

Table 2.2. Prevalence of childhood and adolescent obesity in Bahrain & other Arab Gulf Countries

Country	Year	Sample size	Age (years)	Criteria for overweight/ obesity	Prevalence (%)		Source
					Boys	Girls	
Bahrain	1985	121	7-18	Skinfold thickness ≥85th		19.0	(Blair & Gregory, 1985)
	1989	825	15-21	BMI ≥25	15.6	17.4	(Musaiger *et al.*, 1993)
	1992	584	12-19	BMI 85th –95th		38.5	(Musaiger *et al.*, 2000a)
				BMI ≥ 95th		6.3	
Kuwait	1999	10893	10-13	BMI ≥85th	36.8	35.9	(Al-Mousa & Parkash, 2000)
		10512	14-17	BMI ≥85th	27.6	31.1	
Saudi Arabia	1995	9061	6-18	110-120% of median BMI of reference	11.7		(Al-Nuaim *et al.*, 1996b)
				>120 % of median BMI of reference	15.8		
	1998	597	12-19	BMI ≥ 85th		28.0	(Abahussain *et al.*, 1999)
Oman	1992	596	11-18	BMI ≥ 85th		12.0	(Musaiger, 1994a)

2.2 OBESITY IN BAHRAIN

The Kingdom of Bahrain is an archipelago of 33 islands with a total area of 706,055 square kilometres. The main island of Bahrain is Manama, the capital, where about half of the population lives. The country lies halfway along the Arabian Gulf, which separates it from the State of Qatar in the east, and the eastern coast of Saudi Arabia in the west (see map in Appendix 1A). The latest census of Bahrain, which was conducted in 2001, showed that the total population was 650,604 inhabitants (Central Statistics Organisation, 2001). About 62% of the population is Bahraini, the rest

(38%) are expatriates mainly from the Asian countries and the Far East. The majority of the population (more than 80%) lives in urban areas. In 2001, the estimated Bahraini population under the age of 15 years was 36.5%, indicating a youthful population.

Bahrain is an Arab, Islamic independent state. Recently (on 14 February, 2002) and about a year after a national referendum was voted for by a great majority, Bahrain was pronounced a Constitutional Monarchy and was renamed the Kingdom of Bahrain. Bahrain's economy depends mainly on oil, which was discovered in 1932. Before the discovery of oil, the economy depended on pearl harvesting, agriculture and trading. The need to diversify income resources and reduce the dependence on oil has led to the development of the financial and banking sectors as well as tourism. Since the 1980s, Bahrain has become an important financial centre in both the Arab world and the world in general.

Since the early 1980s several studies have been conducted on the prevalence and determinants of obesity in Bahrain. However, the majority of these studies have focused on the adult population. A study by Amine (1980), in which obesity was defined as ≥120% of the Harvard standard of weight for height, found that 39% of adult females were obese. Al-Mannai *et al.* (1996) examined the levels of overweight and obesity in a sample of 290 adults selected from 2 areas in Bahrain. Results showed that 16% of men and 31% of women were obese (BMI ≥30) and a further 26% and 29%, respectively, were overweight (BMI≥ 25). More recently, Musaiger *et al.* (2000b) found that 56% of the men and 79.6% of the women in Bahrain had a BMI equal to or exceeding 25 kg/m^2.

Data on the occurrence of obesity among adolescents in Bahrain are sparse. An early study by Blair and Gregory (1985) showed that the prevalence of obesity (defined as ≥ 85th percentile of skinfold thicknesses) in a sample of 121 Bahraini girls aged 7-18 years was 19%. Musaiger *et al.* (1993) found that the prevalence of obesity (defined as BMI ≥ 25 kg/m^2) among secondary school male and female students was 15.6% and 17.4%, respectively. A subsequent study on a sample of 584 Bahraini girls aged

12-19 years, which was based on data collected in 1992, showed that the prevalence of overweight (BMI ≥85th percentile of the NHANES reference) among the girls was 38.5% and that of obesity (BMI ≥95th percentile) was 6.3%. The study also showed that Bahraini girls had a higher proportion of body fat than their counterparts in many western countries (Musaiger *et al.*, 2000a).

2.2.1 Factors associated with the development of obesity in Bahrain

During the last three decades and as a result of the increase in oil revenues, Bahrain and other Arab Gulf States have witnessed dramatic changes in the socio-economic status of the population. These transitions are believed to have led to great changes in the food consumption patterns and lifestyle of the population and consequently different trends of diseases and mortality (Musaiger, 2000b). A new pattern of eating, which is characterized by over indulgence in fat-rich foods and the availability of a wide variety of processed food and snacks has appeared, replacing the traditional carbohydrate-based diet. At the same time people have become more sedentary. Television watching has become the favourite leisure activity and with the increased availability of housemaids, cars and labour-saving appliances, the physical activity of the population has markedly diminished (Musaiger, 1987).

Studies investigating socio-demographic correlates of obesity in adults revealed an inconsistent pattern. A study on a sample of 420 women attending a fitness club showed that obesity was more prevalent in women who were unemployed, married and with low level of education. The risk of being obese was also higher among women who did not do exercise before joining the fitness club or who were >30 years of age. Family history of obesity, ownership of cars and availability of housemaids were not significant contributing factors (Musaiger & Al-Ansari, 1992). Another study, which included a random sample of 290 men and women, found that marriage and ownership of a car, as well as family size, were all positively related to obesity, but neither educational level nor family income had any significant association with obesity (Al-Mannai *et al.*, 1996). A more recent study, in which multiple logistic regression was employed to estimate the risk of obesity among Bahraini adults, documented an increase in risk of obesity for those who were females (OR=3.2, 95% CI= 1.96-5.04), educated (OR=1.9, 95% CI=1.1-3.1), with history of hypertension (OR=2.5, 95% CI=1.2-5.1) and who consumed fresh fruit more than 3 times per week (OR=2.0 95% CI=1.3-3.1) (Musaiger *et al.*, 2000b).

Factors associated with childhood and adolescent obesity in Bahrain are not clear. Only a few studies have attempted to assess factors associated with obesity in this age group. However, some possible contributing factors are high intake of calorie-dense foods, lack of physical exercise and socio-cultural factors. Zaghloul *et al.* (1984) examined the daily intake of nutrients and physical activity behaviour in a group of obese and non-obese Bahraini adolescent girls. They found a significantly higher intake of energy, fat, protein and carbohydrates among the obese group compared to the non-obese. The mean daily intake of energy and fat for the obese girls was 2,529 kcal and 79.2 grams, compared to 2,037 kcal and 61 grams for the non-obese, respectively. In addition, 65% of the obese girls were categorized as least active compared to only 29% in the non-obese group. In adults, the physical activity level was also found to be low. The majority of men (>60%) and women (>90%) in Bahrain walked less than one kilometre on average weekdays (Al-Mahroos & McKeigue, 1998) and only 13% of adult males and 8% of females exercised regularly (Musaiger & al-Roomi, 1997). Data from a national growth survey, in which skinfold and arm circumference measurements were carried out on 1,593 Bahraini schoolchildren between the ages of 6 to 18 years, indicated a high subcutaneous fat store and a very small arm circumference, suggesting poor muscle development in these children (Musaiger *et al.*, 1989). Musaiger *et al.* (1993) conducted a study involving 825 secondary school students (417 boys and 408 girls) to examine factors associated with the development of obesity in this population group. Univariate analysis showed that family history of obesity was a significant factor of risk of obesity in male (OR=3.1) and female adolescents (OR=2.6). Obesity was also more prevalent among boys whose mothers were educated and among those who came from small families (<9 family members). Meal pattern and eating habits showed no significant association with obesity, but boys who ate alone were 3 times more likely to be obese than those who ate with their family. Al-Aboudi *et al.* (1995) considered factors contributing to obesity among primary school children (6-12 years). A sample of 603 students (294 males and 309 females) was included in the study. Obesity was defined as BMI $\geq$ 85th percentile of the NHANES-1 standard and information about the socio-economic status of the family was collected from parents via a self-administered questionnaire. Results showed that obesity in children was positively associated with social class and first-born status and was negatively associated with the child's birth order.

Socio-cultural factors such as beliefs and traditions, religion and food preferences exert a powerful effect on the food consumption pattern and lifestyle of populations and consequently their nutritional and health status. Despite the rapid changes in socioeconomic situations and the increased modernization, there is evidence to suggest that in many parts of the Arab world gender discrimination in relation to food distribution and intake may still exist (Musaiger, 1993). In some rural areas of Saudi Arabia, for example, the meal is served first to the male members of the family (which often have the best share of food) and then to the female side of the household, by which time little meat and vegetables may be left (Serenius & Fougerouse, 1981). In Bahrain, Musaiger (1982) found that 72% of the families eat together and in about 13% of the families the two sexes eat separately at mealtime. Furthermore in many Arab Middle Eastern Countries boys are breast fed for longer periods than girls (Musaiger & Harfouuche, 1992). A study on 3-8 month old infants in Jordan revealed that boys receive up to 4 times more meat, fruits and vegetables than girls (UNICEF, 1985 quoted by Musaiger, 1993).

Socio-cultural factors may also exert a differential influence on the physical activity patterns and lifestyles of Arab men and women. Boys for example enjoy a greater freedom to go outside or engage in outdoor activities than girls. They also have greater opportunity to play various sports. Arab women frequently are governed by social customs and traditions that discourage women's active participation in social, economic or leisure activities beyond the home (Arab Women Speak Out, 2002). A study on the main barriers to practising exercise and other recreational activities among women in Bahrain was carried out by Al-Amer (1996). The main social barriers perceived by women were work and home commitment (49%) and care of children (36%). However, 24% of women perceived that the negative attitudes by family members toward women practising exercise/sport to be an important social barrier for them. The study also showed that 79% of the females studied perceived lack of facilities and special clubs for women to be the main reason for not indulging in physical exercise and many (67%) believed that there is sex discrimination as sport and other recreational facilities are always provided for males.

Early marriage and frequent pregnancies may be important factors associated with the increased prevalence of overweight and obesity among women of the Arab Gulf region (Al-Hamad *et al.*, 1999). In Bahrain, for example, obesity is nearly twice as prevalent in women as in men (Musaiger & Al-Roomi, 1997). Although statistics show that age at first marriage is rising in several countries of the Arab world, early marriage is still practiced in many parts of the Arab world (Arab Women Speak Out, 2002).

Perception of body weight is another important area in which cultural and social factors are known to exert a strong influence. In the western countries, where thinness is perceived as the desirable trait for females, girls may find themselves under great pressure to attain a slim figure. However, in some social and ethnic subgroups, beliefs and social norms for ideal or appropriate body size might be a little different. In many Arab countries, overweight is still viewed as a socially acceptable or even desirable trait, especially in women (WHO, 1989; Mokhtar *et al.*, 2001). A study from Kuwait found that despite the high prevalence of obesity among the adult female population (56%), more than half of the women underestimated their weight and about 40% reported weights which were in the overweight category as being appropriate for them (Al-Hamad, 1999). Musaiger *et al.* (1994b) found that 30% of female college students in the United Arab Emirates underestimated their weight. However, there is some evidence that attitudes toward body weight in the Arab Gulf region are changing. In a study to investigate the association between body weight and eating behaviours, and weight control beliefs among Saudi 17 to 25-year-old females, Rasheed *et al.* (1998) documented an increased preference for the modern western thin body image; 37% of the girls in the normal weight subgroup reported dissatisfaction with their body weight and expressed a wish to be thinner, and 62% of the underweight girls said that they do not want to gain weight. A change in the concept of an ideal body image from the overweight female to that of the slim figure was also observed with advancing education.

2.3 HYPOTHESES, AIM AND OBJECTIVES OF THE STUDY

2.3.1 Hypotheses

The hypotheses of the study are:

1. The prevalence of obesity in a representative sample of Bahraini adolescents (12-17 years of age) of both sexes is higher than that previously reported in the literature.
2. Obese adolescents in Bahrain have different environmental risk factors than the non-obese, which are dependent on the socio-economic status, dietary behaviours, physical activity patterns and the family environment.
3. Parental body weight is an important determinant of obesity in adolescence in Bahrain.

Data on the prevalence of obesity among Bahraini adolescents are limited, especially in males. Of the 3 available studies only one has included adolescents of both sexes (Musaiger *et al.*, 1993). Although the results of that study have indicated that 15.6 % of the boys and 17.4 % of the girls were overweight or obese, the criteria used to define overweight or obesity were not appropriate and are therefore questionable. The present study improves on previous studies by using the WHO (1995) recommended criteria for the assessment of overweight and obesity among Bahraini adolescents, in order to allow for a more standardised and internationally comparable definition of obesity. Furthermore, in previous studies, factors contributing to obesity in this age group were not sufficiently investigated, and there have been no studies to examine the relationship between obesity in Bahraini adolescents and risk of developing high blood pressure. This study undertakes a comprehensive examination of these issues pertaining to the development of obesity among Bahraini adolescents.

2.3.2 Aim of the study

The general aim of this study was to determine the prevalence of obesity among adolescents in Bahrain and to investigate factors associated with its development.

2.3.3 Specific objectives

1. To estimate the prevalence of obesity among Bahraini male and female adolescents based on a population representative sample.
2. To identify the characteristics of obesity among adolescents by means of their anthropometric data and body composition indicators.
3. To investigate factors associated with the risk of development of obesity in adolescents, including socio-demographic characteristics, dietary behaviours and physical activity patterns.
4. To describe the relationship between adolescent obesity, parental obesity and the family environment in a sample of obese and non-obese adolescents.
5. To determine the relationship between obesity in adolescents and the risk of developing high blood pressure.
6. To explore the relationship between perception of, and attitudes to, body weight and obesity among adolescents.
7. To develop policy recommendations for the prevention and control of obesity among adolescents in Bahrain.

CHAPTER III: REVIEW OF THE LITERATURE

Childhood and adolescent obesity is a serious public health problem facing the world today (WHO, 2000). Studies indicate that the prevalence of obesity among children and adolescents is increasing and has reached epidemic proportions in many developed and developing countries (Troiano & Flegal, 1998; de Onis & Blossner, 2000). This is a cause of concern since obesity at this age tends to track into adulthood as well as predisposing to cardiovascular diseases and diabetes later in life (Must & Strauss, 1999).

Obesity is a complex disease with multi-faceted aetiology. The current view is that it develops as a result of interactions between biological, environmental and behavioural factors, which act to facilitate the establishment of a prolonged positive energy balance, and consequent weight gain in susceptible individuals. The genetic basis of obesity is well documented. Obesity in parents is a strong predictor of obesity in children (Maffeis *et al.*, 1998). Estimates of the degree to which genetic factors influence body fatness range from 30% to 50% (Bouchard *et al.*, 1998). Despite the importance of genetic predisposition in the aetiology of obesity, only environmental and societal changes can explain the sharp rise in obesity levels that has occurred in many parts of the world and in a relatively short period of time (Prentice & Jebb, 1995).

Research has identified several environmental factors that are associated with increased risk of overweight and obesity in children and adolescents, including high intake of energy dense food, low levels of activity and high levels of sedentary behaviours (Gortmaker *et al.*, 1996). Research also suggests that the family environment in relation to eating pattern and physical activity may play a key role in the development, as well as prevention, of overweight among the offspring, as obesity and risk behaviours tend to aggregate within families (Birch & Davison, 2001; Burke *et al.*, 2001).

3.1 DEFINITION AND MEASUREMENTS

Obesity is defined as the presence of excess adipose tissue, which can be localised or generalised. In adults, obesity and overweight are usually determined using the body mass index. Adults are classified as obese or overweight by a variety of cut-off values based on the mortality and morbidity associated with various levels of BMI. The World Health Organisation has published non-gender specific BMI criteria for overweight and obesity in adults. A BMI value of 25-29.9 kg/m^2 indicates overweight whereas a BMI value of 30 kg/m^2 indicates obesity. The category of obesity is further classified into class I (BMI 30-34.9), class II (BMI 35-39.9) and class III (BMI ≥40) (WHO, 2000). In children and adolescents, however, obesity is difficult to quantify and until recently there has been little agreement on a common indicator of fatness or an established cut-off point to define overweight or obesity in this age group. This is largely because of the increase in weight for height, sexual maturation and the changing body composition that characterizes growth in childhood and puberty.

There are many methods to estimate body fat and to determine whether an individual is obese, such as densitometry, tracer dilution techniques, neutron activation, dual energy x-ray absorptiometry (DEXA), bioelectric impedance analysis (BIA), magnetic resonance imaging (MRI) and computerised tomography (CT). However, most of these techniques are complex, expensive and not practical for use in population studies, and thus their use is restricted to research settings. The only useful population measures of body fat are provided by anthropometry. For the purpose of this study only the anthropometric measurements will be described.

3.1.1 Anthropometric measurements

Anthropometric measurements are often used, particularly in epidemiological studies, as indirect methods to estimate the size of fat mass. The most widely used of these measurements are height and weight indices and skinfold thickness measurements.

3.1.1.1 Weight-height indices

Weight and height are simple and direct measures of body size that are easy to obtain in a variety of settings using relatively inexpensive instruments. Weight is highly correlated with body fat, but because it also correlates with height, which is poorly associated with body fat, weight adjusted for height [W/H^n] is a more useful index with which to assess overweight (Power *et al.*, 1997). There are two types of weight-height indices: relative weight and power type indices.

Relative weight or weight-for-height is a common measure of overweight in children. It expresses the weight of a given subject as a percentage of the average weight of persons of the same height and requires the use of tables of expected weight for the child's height and sex (Power *et al.*, 1997). Several power type indices, which relate weight to the n power of height, have been proposed such as the ponderal index [W/H^3] and the Quetelet's index (also called the body mass index) [W/H^2].

3.1.1.2 Body mass index (BMI)

BMI is one of the most commonly used weight-for-height measures. It can be calculated simply by dividing the body weight in kilograms by the height in meters squared (kg/m^2). BMI offers a reliable and valid measure of obesity in children and adolescents (Rolland-Cachera *et al.*, 1990; Pietrobelli *et al.*, 1998; Malina & Katzmarzyk, 1999). However, the use of BMI as a measure of fatness in children and adolescents may be affected by growth and development as well as by gender differences in body composition (Bini *et al.*, 2000). During childhood and adolescence, BMI varies considerably with age, decreasing in early years and increasing with age after about the age of 6 years. This age dependence of BMI, suggests that the measure is not totally independent of height as it is for adults, who have attained their peak height. Thus the use of BMI in the paediatric population requires a set of sex and age-dependent references. Sexual maturation has also been reported as an important factor producing variations in BMI. Daniels *et al.* (1997) observed that the relationship between percent body fat and BMI was influenced by the stage of pubertal development to a greater extent than it was by age. Despite these limitations, BMI has been recommended as the most acceptable measure of body fat in children and adolescents, especially in population studies, since it is both valid and reproducible, due to it's ease of use (Bellizzi & Dietz, 1999).

3.1.1.3 Skinfold thickness

Total body fat can be predicted from skinfold thickness at various anatomical sites of the body. The most common sites used to assess children and adolescents' adiposity are the subscapular skinfold measurement, which determines truncal body fat and the triceps skinfold, which measures fat in the extremities (Rolland-Cachera, 1993). Several prediction equations for assessing fat mass from skinfold measurement have been developed (Slaughter *et al.*, 1988, Lohman, 1992) and cross validated with other techniques for measuring body fat (Janz *et al.*, 1993; Wong *et al.*, 2000). The clinical validity of skinfold measurement is well established. Triceps skinfold in schoolchildren correlates positively with arteriosclerosis index and systolic blood pressure, and negatively with high-density lipoprotein cholesterol (Kanda *et al.*, 1997). In addition skinfold thickness measurements are simple and relatively inexpensive. However, there is growing concern regarding the comparability of these measurements across surveys and longitudinal studies, which monitor trends over time (Himes, 1989). Reliability is often difficult to establish either for a single observer on the same subject or for different observers, and it tends to decrease as body fat increases. In addition, the need to partially undress may not make this method culturally acceptable in some parts of the world, leading to greater subject refusal and consequently bias (Power *et al.*, 1997).

3.2 CLASSIFICATION OF OBESITY IN CHILDREN AND ADOLESCENTS

Obesity in children and adolescents is difficult to classify based on health outcome criteria similar to those used for adults. Although overweight in adolescents has been shown to be associated with adult morbidity and mortality (Must *et al.*, 1992) as well as with cardiovascular risk factors such as elevated blood pressure and dyslipidemia (Freedman *et al.*, 1999a), available data are currently insufficient to support the development of a risk-factor based classification system for obesity in children and adolescents (Power *et al.*, 1997). Thus a statistical approach is used in which obesity and overweight are defined relative to a selected percentile of a reference population based on age, sex and race or ethnicity. These percentiles may be applied to a variety of anthropometric measures including BMI and skinfold thickness. Several countries have published BMI or skinfold for-age charts for their population as well as defined cut-off points for overweight and obesity. Guillaume (1999) found that obesity cut-off points used in different countries vary considerably. In the United States for example, the 85th and the 95th percentiles of BMI for age and sex are frequently used to identify overweight and obese children, respectively (Must *et al.*, 1991), whereas in some European countries the 90th or 97th percentiles are used to define obesity. An expert panel convened in 1994 recommended that a BMI ≥ 95th percentile for age should be used as a cut-off for overweight, whereas a BMI ≥85th percentile but <95th percentile or a large change in BMI should be considered a risk of overweight and warrants close observation (Himes & Dietz, 1994). The World Health Organisation Expert Committee (WHO, 1995), on the other hand, has recommended the use of both BMI for age and skinfold for age as the best indicators for the assessment of obesity in the adolescent population. Overweight is defined as ≥85th percentile of BMI for age, whereas obesity is defined as ≥85th percentile of BMI for age plus the ≥90th percentile of triceps skinfold for age and the ≥90th percentile of subscapular skinfold for age. A summary of these recommendations is presented in Table 3.1. The WHO has also suggested that in the absence of local reference data, the United States' BMI for age data, published by Must *et al.* (1991), should be used.

More recently, the IOTF has proposed age and sex specific BMI cut-off points for overweight and obesity in children, which are linked to the adult obesity cut-off points of 25 and 30 kg/m^2 (Cole *et al.*, 2000). These cut-offs are based on pooled data from six large nationally representative surveys conducted in Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the United States (Figure 3.1).

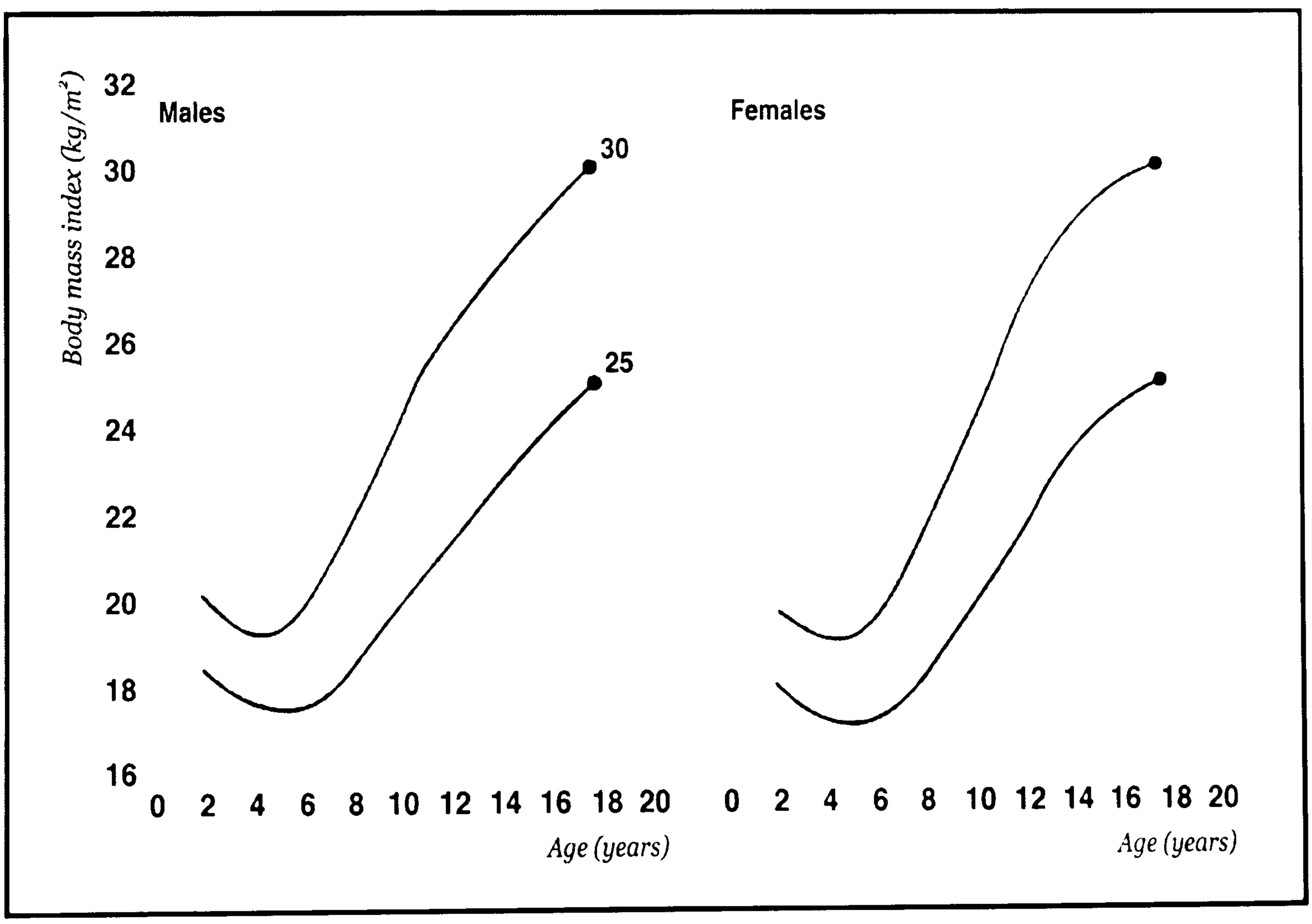
Table 3.1. Recommended cut-offs for overweight and obesity in adolescents

Indicator	Anthropometric indicator	Cut-off
Overweight	BMI for age	≥85th percentile
Obese	BMI for age	≥85th percentile of BMI <u>and</u>
	TSKF for age	≥90th percentile of TSKF <u>and</u>
	SSKF for age	≥90th percentile of SSKF

Source: adapted from WHO (1995)

TSKF= triceps skinfold, SSKF= subscapular skinfold

Figure 3.1. International cut-off points for body mass index by sex for overweight and obesity based on pooled international data.



Source: Cole, *et al.* (2000)

3.3 BODY FAT DISTRIBUTION

There is substantial evidence that the health implications of obesity are not only related to total body fat but also to body fat distribution (Bjorntorp, 1992). In adults, intra-abdominal fat (visceral fat) is related to negative health outcomes independent of total body fat (Bjorntorp, 1992). Current evidence suggests that intra-abdominal fat (IAF) may also be clinically significant in children and adolescents (Goran & Gower, 1999). Excess abdominal fatness in adolescence has been shown to be associated with a number of cardiovascular risk factors that are known to cluster with obesity (Gillum, 1999; Daniels *et al.*, 1999). Studies in which direct measures of IAF (such as MRI and CT) were used showed that early accumulation of IAF is significantly associated with dyslipidemia and basal insulin levels in obese children and adolescents (Caprio *et al.*, 1996; Brambilla *et al.*, 1994).

Traditionally body fat distribution has been assessed by anthropometry. The waist circumference (WC) and the waist to hip circumference ratio (WHR) are often used to predict the health consequences of obesity in adults, as changes in these measurements tend to reflect changes in risk factors for cardiovascular diseases (CVD) and other chronic illnesses. In men and women, an increased WHR (>1.0 for males and >0.8 for females) is associated with greater risk of these diseases independent of total body fat (Bjorntorp, 1992). Furthermore, waist circumference has been identified as the most preferred single anthropometric measurement for assessment of IAF in adults, since it is easy to measure and correlates well with BMI, intra-abdominal fat mass and cardiovascular risk factors (Lemieux *et al.*, 1996). In children and adolescents however, the usefulness of WHR and WC as indices of body fat distribution is not clear. Fox *et al.* (1993) found no significant correlations between these indicators and IAF as measured by MRI in 11 year old boys and girls and suggested that individual trunk skinfold thicknesses (such as the subscapular skinfold thickness) or the ratio of trunk to extremity skinfold thickness (such as the subscapular to triceps skinfold ratio) may be better indicators of intra-abdominal adiposity in children and adolescents. Similar findings were reported in 10 to15 year old children (Brambilla *et al.*, 1994). Recently, however, WC has been shown to be positively and independently associated with CVD risk factors both in children

(Maffeis *et al.*, 2001) and in adolescents (Daniels *et al.*, 1999). Taylor *et al.* (2000) evaluated the validity of WC, WHR and the conicity index (defined as waist circumference ÷ [0.109 × √weight ÷ height]) as indicators of central fat mass in a large sample of 3 to 19 year old children. Results showed that WC correctly identified a high proportion (>90%) of subjects with elevated trunk fat mass as measured by DEXA and that it performed significantly better as an index of trunk adiposity than did WHR or conicity index. The authors concluded that WC could be used to screen for high central obesity in children and adolescents.

3.4 ADOLESCENCE

3.4.1 Definition and characteristics

Adolescence is a significant phase of human growth during which the individual experiences many physiological changes including the spurt in somatic growth, appearance of secondary sexual characteristics, menarche and spermarche. These maturational events begin at pubescence, around the age of 10-12 years in girls and 13-15 years in boys, and continue till the increase in body dimension and other morphological changes culminate in the attainment of the adult status, usually near the end of second decade of life (WHO, 1995). In girls, the most rapid period of growth occurs early in pubertal development and menarche usually occurs after peak height velocity has passed. In boys the growth spurt is more prolonged, taking place later in puberty and is more nutritionally taxing (Poskitt, 1988). During puberty, sex differences in body fatness and distribution of adipose tissue begin to emerge. In girls the main change in body composition is the increase in adipose tissue accumulation, whereas in boys it is the decline in peripheral body fat and increase in lean tissues. Boys also accumulate more intra-abdominal fat than girls (Goran & Gower, 1999).

Adolescence is also a period during which major behavioural and psychosocial changes occur. As children become teenagers they tend to seek greater independence from their parents, and peers become more important in many areas of their lives, both as friends and as role models of behaviour (Shepherd & Dennison, 1996). The eating habits of adolescents may also change as they become increasingly in control of what type of food they eat, where and with whom. Skipping meals, frequent snacking, high consumption of soft drinks and fast foods, as well as frequent dieting are all common features of an adolescent's eating pattern (Bull, 1988). Furthermore, adolescence is also a period of increased awareness of the body, its weight and shape, especially in females. In the western countries, where thinness is perceived as the desirable trait for women, adolescent girls strive to achieve thinness by dieting and other means. A study from the United Kingdom showed that the incidence of dieting was 35% among adolescent girls and that some girls start to diet as early as 8 years of age (Roberts *et al.*, 1999).

Despite its importance as a period of human development, adolescence has received little attention in the health programmes of many countries, including the Gulf States. The emergence of obesity as a global public health problem and the demonstration that obesity in adolescence is associated with adult obesity and its co-morbidities have renewed interest in the health status and anthropometric measurements of adolescents (WHO, 1995).

3.4.2 Adolescence as a critical period for the development of obesity

Recently, adolescence has been suggested as one of the three critical periods of growth, the other two being the prenatal period and the period of adiposity rebound in childhood, when a person is most susceptible to the development and persistence of obesity (Dietz, 1997). Obesity during adolescence is associated with increased adult morbidity and mortality (Must *et al.*, 1992) and increased probability of persistence into adulthood (Srinivasan *et al.*, 1996). The risk of obesity development during adolescence is particularly high in girls. Braddon *et al.* (1986) found that approximately 30% of obese adult females had been obese as teenagers, compared with only 10% in obese adult males. Because the pubertal period is associated with a change in the distribution of body fat, it has been suggested that the effects of obesity present in adolescence on adult morbidity may be mediated by the changes in quantity and location of adipose tissue, particularly the deposition of intra-abdominal fat that takes place around this time (Dietz, 1997).

3.5 ENERGY BALANCE AND THE PHYSIOLOGY OF BODY WEIGHT REGULATION

Body weight is a function of energy balance, which is determined by energy intake and energy expenditure. Obesity develops as a result of small shifts in the energy homeostasis, which over time can lead to a gradual but sustained weight gain. However, physiological studies on humans and animal models support the notion that body weight is regulated by homeostatic mechanisms (Rosenbaum & Leibel, 1998). Despite wide variations in energy intake and expenditure over time, most individuals are able to maintain a relatively stable body weight. Leibel *et al.* (1995) documented significant compensatory changes in the total energy expenditure of adults in response to a 10% gain of body weight induced by overfeeding or a loss of 10-20% of body weight induced by underfeeding.

Energy homeostasis is accomplished through multiple physiological mechanisms (involving the endocrine, gastrointestinal, cardiovascular, central nervous and autonomic nervous system) that act to minimize the impact of fluctuations in energy intake or expenditure on fat mass, thereby maintaining body weight within a relatively narrow range (WHO, 2000). Afferent signals about the body's state of nutrition (flow of nutrients, metabolism and storage) are sent to the brain, which in turn translates them into efferent messages that lead to changes in the energy intake and expenditure so that the energy stores are maintained. It has been suggested that these biological mechanisms operate in an asymmetric fashion, exerting a stronger defence against under-nutrition and weight loss than they do against over-consumption and weight gain (Blundell & King, 1996).

3.6 FACTORS CONTRIBUTING TO THE DEVELOPMENT OF OBESITY

3.6.1 Genetic factors

Studies indicate that genetic factors are predominantly involved in the observed variations in body weight (Perusse & Bouchard, 1999). It is well established that obesity runs in families and that obese children often have obese parents (Guillaume *et al.*, 1995; Maffeis *et al.*, 1994). Parental obesity has also been shown to be important in predicting children's risk of later adiposity (Maffeis *et al.*, 1998b). Whitaker *et al.* (1997) found that parental obesity doubles the risk of adult obesity among both obese and non-obese children and that the risk was greatest for children under 10 years of age. Stunkard *et al.* (1990) found similar correlations of BMI (r = 0.66 and 0.74) in identical twins whether they were raised together or apart. Studies of Danish adoptees revealed a strong association between the relative weight of the adoptees and the weight of their biologic parents, but not their adoptive parents (Stunkard *et al.*, 1986).

The level of heritability, defined as the fraction of population variation in adiposity or BMI that can be explained by genetic transmission, is another issue that has been investigated. Bouchard *et al.* (1998) reviewed several twin, adoption and family studies and found that heritability estimates depend on how the study was conducted and on the type of relatives included. In general heritability levels tend to be highest when obtained from twin studies (50-80%) and lowest when derived from adoption studies (10-30%), whereas studies comparing resemblance in BMI between family members such as pairs of spouses, parents and children and siblings tend to produce intermediate levels of heritability (30-50%). Another statistical method developed to determine the heritability level of traits is the Risch's lambda coefficient (λ_R) (Risch, 1990). In case of obesity, λ_R can be defined as the ratio of the risk of being obese when a biological relative is obese compared to the risk in the population at large, i.e. the prevalence of obesity. Estimates of λ_R for obesity based on BMI data from the United States' national survey (NHANES-II) have shown that the risk of obesity is more than twice in children with obese mothers (λ_R =2.80) or obese fathers (λ_R =2.61) (Allison *et al.*, 1996).

There is increasing evidence that genes are also involved in determining the effect of various lifestyles and dietary interventions on BMI. Bouchard and colleagues (1990 & 1994) performed a series of experiments to investigate the role of genotype in determining the response to changes in energy balance. The researchers subjected both members of male monozygotic twins to a positive energy balance (induced by long term overfeeding) or a negative energy balance (induced by long term exercise training). The results showed significant changes in body weight and adiposity, but the variations in the responses tended to be greater between pairs than within pairs, suggesting a genetic basis for the susceptibility of individuals to gain or lose weight.

The role of genetics in the development of excess fatness has been further demonstrated by the discovery of leptin, the product of the ob gene. Leptin is a critical regulator of body fat stores and plays an important role in many animal models of obesity. The role of leptin in the aetiology of human obesity is not clear. Only a few cases of severe obesity have been shown to be due to a deficiency in leptin resulting from mutations in the leptin gene (Montague *et al.*, 1997) or in the leptin receptor gene (Clement *et al.*, 1998). Most people, however, do not have defects in the genes encoding for leptin or it's receptor and some obese people have been shown to have higher leptin levels than lean people (Considine *et al.*, 1996). It has been suggested that obesity in humans may be associated with functional leptin resistance due to defective leptin transport or alterations in the intracellular signalling triggered by leptin binding to its receptor (Hoppin & Kaplan, 1999). Other rare single gene defects that have been implicated in human obesity include mutations in the prohormone convertase-I gene (PC1), in the pro-opiomelanocortin gene (POMC) and in the melanocortin-4-receptor gene (MC4R) (Perusse & Bouchard, 1999). However, it is believed that in the majority of cases, these genes do not act directly to cause obesity but rather they increase susceptibility of individuals to weight gain when certain environmental influences that have the potential of causing shifts in the energy balance equation are present.

3.6.2 Dietary factors

Food intake plays a key role in the energy balance equation. It is well known that the prevalence of obesity is higher in affluent populations with higher caloric intake than in poor regions (WHO, 2000). On the individual level, however, the relationship between energy intake and obesity is less clear and there is little evidence to support the hypothesis that overeating in adults or children causes obesity. Although relative overeating has been reported in some obese individuals, most studies have failed to demonstrate that obese children and adults eat significantly more than non-obese children and adult subjects (Rolland-Cachera & Bellisle, 1986; Kromhout *et al.*, 1988; Rocandio *et al.*, 2001). However, there has been increased concern over the validity of these reports, as obese individuals tend to underestimate their food intake. A study by Bandini *et al.* (1990) in which energy expenditure was estimated and used to assess the validity of the reported food intake of obese and non-obese adolescents, showed that obese adolescents reported only 58% of their energy intake compared to normal weight children who reported 81% of their intake.

Dietary fat plays an important role in the development and maintenance of obesity. Nutritional studies indicate that obesity is related to high fat intake in children and adolescents (Garaulet *et al.*, 2000; Gazzaniga & Burns, 1993) and in adults (Lissner & Heitmann, 1995). Guillaume *et al.* (1998) demonstrated a strong positive relationship between obesity and the fat content of diet in 8 to 12 year old children. McGloin *et al.* (2002) compared the energy and fat intake of obese children and lean children at high risk and low risk of obesity. The results showed that obese children consumed significantly more fat than their lean counterparts. In addition, fat intake was a strong predictor of obesity in the children, independent of parental weight status. Compared to proteins and carbohydrates, fats provide more calories per gram and are more efficiently stored in the body. Furthermore, high fat foods are more palatable, which often leads to over-consumption. Obese individuals have been shown to have a high preference to high-fat foods compared to underweight and normal weight individuals (Drewnowski *et al.*, 1991). The physiologic responses to high fat meals, which include delayed gastric emptying and increased cholecystokinin release, suggest that fat intake may suppress appetite. However, experiments in which the food intake of subjects was measured after covert preloads suggested otherwise. Blundell *et al.* (1993) found that a 362-kcal carbohydrate supplement suppressed appetite when measured 90 minutes after consumption. In contrast a 362-kcal fat supplementation had no effect on subsequent appetite, resulting in a net increase in energy intake. The role of the macronutrient composition on total energy intake was further investigated by the indirect calorimetry study of Stubbs *et al.* (1995) in which three manipulated diets which were low, medium or high in fat were used. The results showed that increasing the fat content and energy of the diet led to a substantial increase in the energy intake of subjects. The researchers concluded that fat intake is less well controlled than protein or carbohydrate intake and that exposure to a diet with high fat content may be responsible for the weight gain in obese individuals.

3.6.2.1 Dietary behaviours of adolescents

Adolescence is a time of changes, both biological and psychosocial. It is also the time when new dietary habits are acquired, and influence of peer pressure on food choices emerge. The diet of adolescents and young people is characterised by several specific eating behaviours, including eating away from home, high intake of fast foods, frequent snacking, un-healthy dieting and skipping meals. These behaviours may induce adverse nutritional conditions, including overweight and obesity (Bull, 1988).

Fast food can be defined as food purchased in self-service or carry-out eating places without waiter service. French *et al.* (2001) examined the associations between frequency of fast food restaurant use (FFFRU) and nutrient intake and body weight in a large sample of American adolescents. The results showed that FFFRU was significantly and positively associated with total energy intake and percentage of energy from fat, total fat and saturated fat. FFFRU was also associated with higher intake of high fat and high sugar food choices such as soft drinks, french fries and cheeseburgers, and lower intake of healthful food choices such as fruits, vegetables, grains and milk. However, no association was observed between FFFRU and obesity in the adolescents, but a previous study by the same researchers on women demonstrated a significant relationship between high consumption of fast foods and greater body weight (French *et al.*, 2000).

Skipping meals and frequent snacking are common features of adolescents' eating pattern. About 20% of children in Western Europe admit to skipping breakfast (Rolland-Cachera *et al.*, 2000). A survey on 13-year-old Australian children showed that girls were three times more likely to skip breakfast than boys. In addition, children who skipped breakfast were more likely to be dissatisfied with their weight and to have been on a diet than those who ate breakfast (Shaw, 1998). Summerbell *et al.* (1996) found a significant negative association between energy intake at breakfast and BMI in adolescent British girls. In a large study investigating environmental factors contributing to obesity in 4 to 17-year-old Chinese children, Guansheng (2001) found that children who often skipped breakfast were more likely to be obese than those who ate breakfast daily; and children who often consumed fast foods were more likely to be obese. Snacking is an increasingly prevalent eating behaviour among adolescents in Western countries (Jahns *et al.*, 2001). Summerbell *et al.* (1995) compared meals versus snacks in terms of their contribution to total daily energy intake and macronutrient composition. It was found that snacks make a relatively high contribution to the total energy intake of British adolescents (23.6% to 29.0% of total daily energy intake) and that compared to meals, snacks have a relatively high sugar composition and a relatively low fat and protein content.

It has been suggested that the high incidence of meal skipping and unstructured meal patterns observed in the West is the product of modern society, which promotes a lifestyle for parents and adolescents that leaves less time for family meals and food preparation (Bull, 1988). Data from the Rosetto Study already suggests that social cohesion, family ties and the supportive nature of the community may play a protective role against coronary heart disease (Egolf *et al.*, 1992) and this may also be true for obesity. Having meals with the family may guard against eating calorie-dense food and weight gain, which are associated with snacking and eating away from home. Thakur and D'Amico (1999) found that obese adolescents were more likely to report infrequent meals with the family than non-obese adolescents. Gillman *et al.* (2000) examined the relationship between the frequency of eating dinner with the family and eating patterns of US children and adolescents. It was found that eating dinner with the family was associated with higher intake of fruit and vegetables, lower intake of fatty foods and soda, and greater micronutrient and fiber consumption; but no significant difference was observed in the intake of snack foods and red meat.

3.6.3 Physical activity

Physical activity is a key component of the expenditure aspect of the energy balance equation providing a major outlet for daily caloric usage. Studies indicate the existence of an inverse relationship between adiposity and physical activity both in adults (King *et al.*, 2001; Schulz & Schoeller, 1994) and in children and adolescents (Trost *et al.*, 2001; Deheeger *et al.*, 1997; McMurray *et al.*, 2000). Kemper *et al.* (1999) examined the relationship between the development of fat mass in males and females (12 to 28 years of age) and their lifestyle over time. It was found that high physical activity was associated with reduced risk of developing high fat mass. Using the doubly labelled water technique to estimate total energy expenditure, Davies *et al.* (1995) observed a significant negative relationship between physical activity level and body fatness in pre-school children. Other investigators, however, found no association between physical activity level and children's weight or body fat (Sallis *et al.*, 1993; Bar-Or *et al.*, 1998).

Inactivity is a potential source of energy imbalance. The rapid increase in the prevalence of obesity in the industrialised countries has been accompanied by a parallel reduction in physical activity and a rise in sedentary behaviours, suggesting that inactivity could be a major factor in the development of obesity (Prentice & Jebb, 1995). Inactivity can be defined as a state when body movement is minimal and energy expenditure approximates resting metabolic rate (Dietz, 1996). It includes sedentary behaviours such as television viewing, reading, talking with friends on the telephone or driving a car. One of the most common sedentary behaviours is television viewing. Several studies have shown that television viewing was strongly and consistently related to increased risk of obesity in children and adolescents (Hernandez *et al.*, 1999; Dietz & Gortmaker, 1985; Andersen *et al.*, 1998). Gortmaker *et al.* (1996) demonstrated a dose-response relationship between the number of hours of television viewing and the incidence of obesity. Over a 4-year period, adolescents who watched 5 or more hours of television per day were 8 times more likely to become obese than those watching for 2 hours or less. Intervention studies have yielded further evidence in support of this relationship. Epstein *et al.* (2000) reported that decreasing TV viewing and other sedentary activities or increasing physical activity produced significant and similar reductions in body fatness in children. In a randomised controlled trial, which targeted hours of TV, videotape and video games use, Robinson (1999) documented a direct association between these activities and adiposity in children. Other studies however, could not find a significant association between TV watching time and adiposity in young children (DuRant *et al.*, 1994) or in adolescents (Robinson *et al.*, 1993).

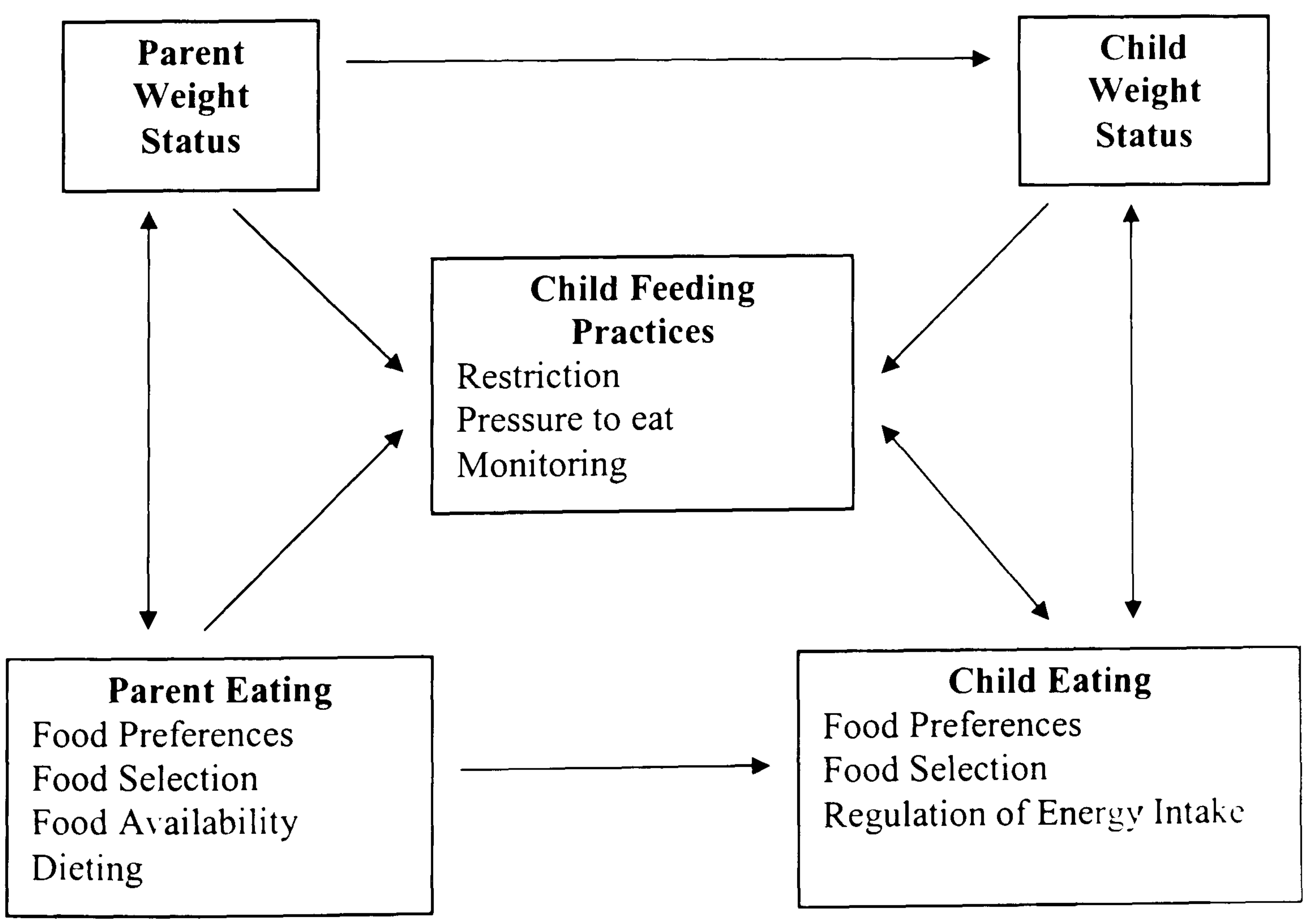
The mechanism by which television viewing can influence body weight is not clear. It has been suggested that TV viewing can induce weight gain by reducing total energy expenditure secondary to lowering resting metabolism or displacement of physical activity (Robinson, 2001). Klesges *et al.* (1993) observed a significant reduction in resting metabolic rate (RMR) associated with television viewing among both obese and non-obese children. Other investigators however, failed to detect any significant association between RMR and sedentary behaviours such as sitting, reading or television viewing (Dietz *et al.*, 1994). Television viewing may contribute to weight gain by reducing the opportunity to be outdoors and hence time spent in more energy-demanding activities. TV viewing may also promote greater energy intake, through encouraging excessive snacking while watching television as well as through exposure to TV food commercials. French *et al.* (2001) found that TV viewing was positively associated with frequency of fast food restaurant use in adolescents.

3.6.4 Factors related to the family environment

Studies of family aggregation of obesity indicate that family environmental influences play a significant role in determining risk of overweight among children (Maffeis *et al.*, 1994; Birch & Davison, 2001). Familial resemblance in total energy intake and adiposity is well documented (Oliveria *et al.*, 1992; Nguyen *et al.*, 1996). Feunekes *et al.* (1998) reported a clear likeness in habitual food and fat intake between spouses and between parents and their adolescent children, but not between teenagers and their best friends. Fisher and Birch (1995) found that pre-school children demonstrate a high fat preference if their parents are obese. Parents may influence the food intake of children in a variety of ways, including serving as models for dietary habits, persuading or encouraging the child to consume or avoid a certain food and by attempting to change the children' eating habits through use of restriction, pressure or coercion (Birch & Davison, 2001). Klesges *et al.* (1986) found that parental prompts to eat were positively associated with time spent eating and degree of overweight in children. Johnson and Birch (1994) showed that parents who exert excessive control over their children's eating choices may interfere with the child's ability to regulate his/her food intake in response to meal size or composition. Lee *et al.* (2001) observed a greater use of restriction and pressure to eat among mothers of girls consuming a high fat diet than among mothers of girls consuming a low fat diet. More recently, Spruijt-Metz *et al*, (2002) investigated the relationship between a mother's child-feeding strategies and a child's adiposity assessed by DEXA in a sample of 7 to 14 year-old-children. Results showed that a mother's concern for her child's weight was related to higher total fat mass in the child, whereas a mother's pressure to eat was related to lower total fat mass. However, other investigators found no significant association between parental control over children's eating and overweight in preadolescents (Robinson *et al.*, 2001). Birch and Davison (2001) have proposed a conceptual model of how familial factors influence children's eating and body weight (Figure 3.2). Pathways that mediate familial resemblances of overweight include parents' own eating behaviours and their parenting practices, which in turn influence the development of children's eating behaviours such as food preference, food selection and ability to regulate energy intake based on hunger and satiety. In particular, parents who are overweight or who have problems controlling their food intake may serve as models for children developing eating behaviours. In addition, parents who are concerned about their child's risk of becoming overweight may adopt controlling feeding practices such as restriction and pressure in attempts to reduce risk or to prevent overweight in their children. However these practices are problematic since they can promote overeating and consequently weight gain in the children.

Parents' physical activity is another important family environmental factor influencing the child's weight status. There is accumulating evidence that children's level of physical activity is determined to a large degree by the activity level of their parents (Sallis *et al.*, 1988a; Sallis *et al.*, 1988b). Using electronic motion sensors to compare the rates of activity between children and their parents, Moore *et al.*(1991) found that children of active mothers or fathers were 2-3 times more likely to be active than children of non-active parents. When both parents were active, their children were approximately 6 times more likely to be active compared to children of inactive parents. Similarly, Fogelholm *et al.* (1999) found that parental inactivity is a strong predictor of child inactivity and that the correlation between children and their parents in relation to inactivity was stronger than that of vigorous activity. Parents may influence the physical activity behaviour of their children by being active themselves (modelling) as well as by providing encouragement and support (Lau *et al.*, 1990). Genetic factors may also play a role in determining the child's activity level. Family and twin studies that have investigated the genetic determinants of sport participation and daily physical activity estimated a heritability coefficient ranging from 0.29-0.83 (Beunen & Thomis, 1999).

Figure 3.2. Behavioural mediators of family resemblances in eating and weight status



Source: Birch & Davison (2001)

3.6.5 Perinatal factors

The prenatal and early postnatal periods have been suggested as critical stages for the development of obesity. Several lines of evidence suggest that nutritional alterations during these early stages of human development can result in significant physiological changes, which predispose individuals to later fatness (Dietz, 1997). However, the relationship between fetal nutrition, for which birthweight is used as a crude indicator, and subsequent obesity is not clear and inconsistent results have been reported. Barker *et al.* (1997) found that low birthweight was associated with abdominal fatness in adolescent girls as well as with increased risk of hypertension, cardiovascular diseases, diabetes and hyperlipidemia in adult life (Barker *et al.*, 1993; Barker, 1997). Barker's group hypothesised that reduced growth in-utero may exert a "programming" effect, which leads to long-term changes in body composition, physiology and metabolism. In contrast, several other investigators have reported the existence of a direct association between birthweight and risk of obesity in adolescence (Maffeis *et al.*, 1994; Seidman *et al.*, 1991; Burke *et al.*, 2001) and in adulthood (Curhan *et al.*, 1996; Rasmussen & Johansson, 1998). For example, Maffeis *et al.* (1994) found that high birthweight was a significant predictor of risk to overweight in 4 to 12-year-old children, independent of age and parents' BMI. Follow-up studies of infants exposed to famine prenatally also support a role for intrauterine factors on future adiposity. Ravelli *et al.* (1976) showed that the incidence of obesity was increased in youth whose mothers were exposed to famine during the first two trimesters of pregnancy. In contrast, exposure to starvation during the last trimester of pregnancy or during early infancy was associated with reduced risk of subsequent obesity. These results were interpreted in relation to certain intrauterine events, namely the differentiation of the brain's appetite control centre during early and mid-gestation, and adipose tissue cellularity during the last trimester and postnatal period (Dietz, 1994). Exposure to under-nutrition during early gestation may promote weight gain by interfering with structures involved in regulation of energy intake, whereas exposure to over or under-nutrition during late gestation or postnatal period can predispose to, or protect against, later obesity through influencing fat cell multiplication. This was further supported by the observation that intra-uterine diabetes or the use of insulin by diabetic mothers during pregnancy increases the risk of later obesity in the offspring (Pettitt *et al.*, 1983; Whitaker & Dietz, 1998). Such increased risk is independent of maternal weight, suggesting that altered intrauterine environment rather than genetic factors mediates the effect of maternal diabetes on children's susceptibility to fatness.

Breastfeeding has been suggested to have a protective effect against the development of obesity later in life (Liese *et al.*, 2001; von Kries *et al.*, 1999). In a large sample of German schoolchildren 5 to 6 years of age, von Kries *et al.* (1999) found that the prevalence of obesity in breast-fed infants was 2.8% compared to 4.5% in those who had never been breast-fed. In addition there was a clear dose-response relationship between the duration of breastfeeding and the prevalence of obesity and overweight among the children. Recently, Parsons *et al.* (1999) reviewed studies that have investigated the relationship between duration of breastfeeding and risk of obesity measured in children aged 2 to 7 years. Of the six studies reviewed, 3 found no relationship, one study suggested a negative relationship, one study suggested a positive relationship and one study reported either no or positive association, depending on the outcome variable analysed. It was concluded that no clear evidence exists for an effect of infant feeding on later fatness in children 2-7 years of age. Dietz (2001) has suggested that the age at which the consequences of mode of infant feeding become apparent may account for the lack of significant effects in studies with relatively short periods of follow-up. Studies in which risk of overweight associated with infant feeding practices was measured during adolescence showed that breastfeeding provides a significant protective effect against subsequent obesity (Tulldahl *et al.*, 1999; Elliott *et al.*, 1997). Gillman *et al.* (2001) found that children who were predominantly breastfed during the first six months of life had a significantly lower risk of overweight 9 to 14 years later (odds ratio=0.78, 95% CI=0.66-0.91) than those who were predominantly formula fed, independent of sex, age, sexual maturity, socio-economic status, energy intake, maternal BMI and other lifestyle variables. In addition longer periods of breastfeeding (7 months or more) were associated with a 20% reduction in risk of overweight than a short period of breastfeeding (3 months or less).

The mechanism by which breastfeeding protects against the development of obesity is not clear. Von Kries *et al.* (1999) suggested that the protective effects of breastfeeding might be related to differential changes in plasma insulin concentrations following the ingestion of breast milk or formula milk. Lucas and co-workers (1980) detected a greater increase in after-feed plasma insulin levels in bottle-fed infants compared to breastfed-babies. Since insulin stimulates glucose uptake and promotes fat storage, it was hypothesised that ingesting bottle milk may promote adiposity through triggering insulin-induced fat deposition in infancy. Alternatively, differences in infants' risk to obesity may be related to overfeeding of formula-fed infants (Birch & Fisher, 1998). Bottle-feeding promotes greater maternal control since the mother can see how much milk the infant has consumed and thus may be more inclined to have the infant finish the bottle even when satiated. In contrast, breastfeeding allows the infant to have a greater control over the size of the feed and consequently a better regulation of energy intake in response to internal signals of hunger and satiety.

3.6.6 Socio-economic influences and other factors

Socio-economic factors are one of the most extensively studied environmental determinants of obesity. This is mainly because of their potential to affect many other variables influencing child weight status. However, the relationship between social factors and childhood fatness is still equivocal, with some studies reporting a significant relationship (Rolland-Cachera & Bellisle, 1986) and others not finding a relationship (Sobal & Stunkard, 1989). In a comprehensive review that included 144 studies from different countries worldwide and different age groups, Sobal and Stunkard (1989) found a strong negative relationship between socio-economic status (SES) and fatness in women from the developed societies. Among men and children, however, no clear relationship was detected. In contrast, studies from the developing countries were more consistent, reporting a direct association between SES and obesity in both men and women and in children. Recently, Parsons *et al.* (1999) reviewed the role of childhood environmental factors, including SES, in later obesity. Socio-economic status in childhood was defined on the basis of parents' education, occupation and/or income. Almost all of the longitudinal studies reviewed showed a strong negative relationship between SES in childhood and fatness in adulthood. Men and women with a lower social class of origin (i.e. during childhood) had a greater risk of adult obesity than those from higher SES backgrounds, suggesting that socio-economic environment in childhood is an important factor influencing the risk of the development of adult obesity. Studies in which the risk of subsequent obesity was measured in childhood showed a similar but somewhat less consistent trend.

Social class can influence energy balance through its effects on behaviours. Lower SES individuals may eat more calories or eat a higher fat diet. Rolland-Cachera and Bellisle (1986) found that the higher prevalence of overweight among French children from lower social classes was related to their traditional diet, which is characterised by greater calorie intake. Physical inactivity of low SES children may also be an important consideration in the risk of overweight. A study conducted to examine the influence of physical activity (PA), TV viewing, video game playing, SES and ethnicity on the weight status of adolescents showed that SES was an important determinant of BMI (McMurray *et al.*, 2000). When SES and ethnicity were adjusted for, no significant relationship was found between overweight and television viewing or video game playing, but the association between PA and obesity persisted. It was concluded that physical inactivity rather than PA habits might be responsible for the observed SES-obesity relationship in adolescents.

The SES-obesity relationship may be a sign of educational and cultural differences. High SES persons may have a greater access to health information, more opportunities to engage in leisure time physical activities, a greater variety of low fat foods and may have different norms and expectations regarding personal appearance and lifestyle than low SES individuals. Jeffrey and French (1996) showed that among women, social class was positively related to healthy weight control practices (such as reducing energy and fat intake and increasing exercise) and weight concerns, but was negatively related to energy intake and fat intake. Story *et al.* (1995) examined differences in perception of body weight, unhealthy eating behaviours and weight control methods among 36,320 male and female adolescents of various ethnic and socio-economic subgroups. It was found that male and female adolescents of high SES were less likely to use unhealthy weight control practices such as binge eating and vomiting compared to low SES adolescents. The study also showed that among girls, higher SES was associated with perception of overweight, frequent dieting and adoption of healthy eating and exercise behaviours. These results support the argument that higher SES individuals engage in healthier lifestyles that are reflected in a variety of behaviours.

Psychological conditions have been suggested as possible underlying factors that may explain the pattern of the SES–childhood obesity relationship observed in the developed world (Power & Parsons, 2000). Emotional problems during childhood may be associated with increased risk of obesity later in life. Lissau and Sorensen (1994) documented a 7-fold increase in risk of obesity at age 20 years for children in a non-supportive home environment and a 10-fold increased risk of obesity in children who were neglected. The authors hypothesised that parental neglect may lead to children developing psychological states that affect their weight status by altering behaviours, such as promoting overeating and decreased physical activity. Emotional deprivation and psychological trauma may also trigger stress responses through activation of the hypothalamic-pituitary-adrenal axis, which in turn can predispose to abdominal obesity.

Alternatively, the SES-obesity relationship could be related to differences in body image. The way people view their body and how they feel about their body may affect the way they respond to weight changes and weight control. Obesity may be differently viewed in different cultures and ethnic groups. Several studies have shown that white or high-SES adolescents exhibited greater dissatisfaction with their body size than black or low SES adolescents (Desmond *et al.*, 1989; Kemper *et al.*, 1994; Story *et al.*, 1995). Kemper *et al.* (1994) found that the female body size considered ideal by black teenage girls was significantly larger than the size selected as ideal by their white counterparts. Black girls were also twice as likely as white girls to describe themselves as thinner than other girls their age, and seven times more likely to say that they were not overweight.

3.7 CONSEQUENCES OF OBESITY

The health consequences of childhood and adolescent obesity are many and varied, ranging from social and psychological problems to metabolic disturbances and increased risk of adult morbidity and mortality. Childhood obesity often persists into adulthood and many of the metabolic side effects of obesity are already evident in overweight children. Increased growth and early maturation is another common effect of childhood obesity. Less common consequences include orthopaedic problems, gallstones, liver disease, sleep apnea, and psuedotumor cerebri. Table 3.2 lists some of the complications of childhood and adolescent obesity.

Table 3.2. Health consequences of childhood and adolescent obesity

High prevalence	Intermediate prevalence	Low prevalence
Faster growth	Hepatic steatosis	Orthopaedic problems
Psychosocial problems	Abnormal glucose metabolism	Sleep apnea
Adult obesity	Adult obesity	Pseudotumor cerebri
Dyslipidemia		Cholelithiasis
Elevated blood pressure		Hypertension
		Polycystic ovary syndrome

Source: WHO (2000)

3.7.1 Effect on growth

Overweight children tend to be taller and mature earlier than normal weight children. In a longitudinal study on children who developed obesity during childhood, Forbes (1977) observed a tendency for height gain to accelerate coincident with or shortly after excessive weight gain. Early maturation, determined by skeletal age, peak height velocity and age at menarche have been shown to be associated with increased fatness in later stages of life (van Lenthe *et al.*, 1996). The timing of maturation appears to be determined by both genetic and environmental factors. Frisch and McArthur (1974) suggested that the onset of menarche in girls depends on the presence of a critical mass of body fat and that this critical level of adiposity may be responsible for the cessation and resumption of menstruation in women with anorexia nervosa before and after treatment. More recently, Chehab and co-workers (1997) observed that mice treated with leptin demonstrated earlier fertility than untreated mice, suggesting a possible role of adiposity in the onset of reproductive functions. In a longitudinal study that examined changes in plasma leptin concentrations and body fat mass during adolescence, Ahmed *et al.* (1999) detected sexual dimorphism in leptin levels in adolescents, which paralleled that seen in body composition. The authors concluded that leptin might play an important role in the initiation of puberty.

3.7.2 Metabolic disturbances

Childhood and adolescent obesity is associated with a wide variety of metabolic side effects, including dyslipidemia, altered glucose tolerance, insulin resistance and hyperinsulinemia (Freedman *et al.*, 1999a). Dyslipidemia is a metabolic state in which plasma levels of triglycerides (TG), low-density lipoprotein-cholesterol (LDL-C) and high-density lipoprotein-cholesterol (HDL-C) are abnormal. In obese children dyslipidemia is characterised by elevated plasma levels of TG and LDL-C and reduced concentrations of HDL-C. These obesity-induced metabolic alterations are not only evident in the obese child but can also track into adulthood. A 14-year follow-up study of 783 children aged 13 to 17 years (The Bogalusa Heart Study) has shown that compared to their lean counterparts, subjects who were overweight during adolescence had a 2.4, 3 and 8-fold increase in the prevalence of high risk values for total cholesterol, LDL-C and HDL-C during adulthood, respectively, (Srinivasan *et al.*, 1996). The study also showed that being overweight in adolescence was associated with adverse levels of insulin, glucose and blood pressure later in life.

Glucose intolerance and NIDDM are among the most frequent side effects of adult obesity and recent evidence suggests that the prevalence of these disorders is also increasing in obese children and adolescents. A study from a children's hospital in the United States has documented a 10-fold increase in the incidence of NIDDM among adolescents between 1982 and 1992 and that the vast majority (90%) of the diabetic children were obese (Pinhas-Hamiel *et al.*, 1996). Data from the Bogalusa Heart Study showed that all of the subjects who showed evidence of diabetes as adults were overweight during adolescence (Srinivasan *et al.*, 1996).

The mechanism by which childhood obesity predisposes to NIDDM is not completely understood. Excessive fatness in pubertal children has been shown to be associated with hyperinsulinemia and changes in sensitivity to insulin (Steinberger *et al.*, 1995; Sinaiko *et al.*, 2001). These endocrine disturbances are believed to play a key role in the pathogenesis of syndrome X (also called insulin resistance syndrome). Syndrome X is a multiple metabolic disorder that is commonly seen in obese adults. It is characterised by the co-presence of hypertension, hyperinsulinemia, insulin resistance, and dyslipidemia. In adults, syndrome X predisposes to NIDDM and CVD and several lines of research suggest that many of its metabolic abnormalities originate in childhood. Steinberger *et al.* (2001) observed a strong longitudinal relation between adiposity in childhood and insulin resistance in young adulthood; BMI at age 13 years was negatively correlated ($r= -0.5$, $P= 0.006$) with insulin-induced glucose utilization, assessed using the euglycemic insulin clamp technique. A more recent community-based longitudinal study, which included a cohort of 745 subjects aged 8-17 years, showed that the prevalence of clustering of abnormalities associated with syndrome X among adults increased with increasing levels of childhood BMI and insulin. The multivariate analysis showed that both obesity and insulin levels during childhood are significant and independent factors associated with the risk of developing syndrome X in adulthood (Srinivasan *et al.*, 2002).

3.7.3 Effect on blood pressure

The adverse impact of childhood and adolescent obesity on blood pressure levels is well recognised (Freedman *et al.*, 1999a; Leccia *et al.*, 1999; Williams *et al.*, 1992). Although hypertension is a somewhat uncommon disease in the paediatric population, a significant proportion (56%) of children with elevated blood pressure are obese (Rames *et al.*, 1978). Figueroa-Colon *et al.* (1997) found that approximately 20% to 30% of obese children aged 5-11 years have elevated systolic

(SBP) or diastolic blood pressure (DBP). Furthermore, childhood obesity is a powerful predictor of adult blood pressure. Lauer and Clarke (1989) found that obese adolescents were 9 to 10-fold more likely to develop high blood pressure as young adults than non-obese children. These findings were in agreement with the results of Srinivasan *et al.* (1996), who documented an 8.5-fold increase in risk of adult hypertension among overweight adolescents, compared to their lean counterparts. The effects of obesity present in adolescence on blood pressure levels may be related to the accumulation of abdominal fat that occurs around the time of puberty. Shear *et al.* (1987) have documented a significant positive association between central obesity as measured by subscapular skinfold and blood pressure in children and young adults, which persisted even after controlling for triceps skinfold. Lurbe *et al.* (2001) used ambulatory BP monitoring to assess the impact of obesity and body fat distribution on BP in children and adolescents. Results showed that casual and ambulatory SBP were positively correlated with height, weight, the ponderal index, triceps and subscapular skinfold, and WHR. When multiple regression analysis was performed, WHR rather than obesity or body size parameters was the main determinant of ambulatory BP. When these researchers evaluated the relationship between WC and SBP, waist dimension was found to be positively and independently related to SBP, indicating a role for central obesity in elevated blood pressure. However, other researchers could not detect a significant influence for fatness or fat patterning on blood pressure in adolescents (Stallones *et al.*, 1982; Leccia *et al.*, 1999).

It has been postulated that obesity contributes to hypertension by causing hyperinsulinemia, increased sympathetic nervous system activity and activation of the renin-angiotensin system, all of which can lead to enhanced renal absorption of sodium and reduced natriuresis. Sodium retention results in extracellular fluid expansion and increased cardiac output, which ultimately lead to hypertension (Hall, 1997). Rocchini (1989) investigated the role of sodium in the regulation of BP in obese and non-obese adolescents. The adolescents were subjected to a 2-week period of a high salt diet and a low salt diet, and the mean arterial pressure was compared as subjects were switched from high to low sodium diet. It was found that obese adolescents demonstrated a significantly larger decrease in blood pressure than the non-obese. Plasma insulin, aldosterone and nor-epinephrine levels, and percent body fat were all significantly associated with the degree of sodium sensitivity. It was concluded that the blood pressure of obese adolescents is more dependent on dietary sodium than that of lean adolescents and that this sensitivity may be due to the combined effects of the hyperinsulinemia and increased activity of the sympathetic nervous system.

3.7.4 Persistence into adulthood

The risk of childhood obesity and its continuation into adulthood is now well recognized (Must & Strauss, 1999). About a third of obese pre-school children and about half of the obese school-aged children become obese as adults (Serdula *et al.*, 1993). In a longitudinal study that assessed the risk present in childhood for adult obesity, Guo *et al.* (1994) found that the odds ratio for obesity at age 35 years increased from about 2 for boys and girls who were obese between the ages of 1-6 years, to 5 to 10 for children who were obese at ages 10-14 years. The odds for subsequent obesity at ages 16-18 years were even higher, ranging from 6 to 57. Srinivasan *et al.* (1996) found that the risk of overweight adolescents remaining overweight as young adults ranged from 50% to 60%. However, a recent longitudinal study, which involved 932 subjects from Newcastle, UK, found little evidence of obesity tracking from childhood to adulthood. BMI at age 9 years was strongly correlated with BMI at age 50 years, but was not correlated with percent body fat. The authors suggested that the observed association between childhood obesity and adulthood obesity may be due to tracking of body build rather than fatness (Wright *et al.*, 2001).

Sex, age, degree of fatness and family adiposity all appear to be important factors in determining the degree of persistence of fatness. Overweight female adolescents have a greater likelihood of continued obesity into adult life than overweight male adolescents. Braddon *et al.* (1986) found that among individuals who were obese at the age of 36 years, 14% of males and 32% of females were obese at the age of 14 years. Srinivasan *et al.* (1996) found that the risk of becoming an overweight adult was greatest among children who were overweight at or around puberty and among those who were at higher levels of obesity. Rolland-Cachera *et al.* (1987) found that the age of adiposity rebound in children predicts adult BMI. A longitudinal study in which the odds ratios across childhood for the risk of adult obesity were examined, showed that the probability for the persistence of obesity increases with the age of the obese child, and when both parents are obese (Whitaker *et al.*, 1997).

3.7.5 Risk of adult morbidity and mortality

Adolescent obesity is associated with increased morbidity and mortality in adult life. Mossberg (1989) showed that excessive overweight in puberty was associated with higher than expected mortality and morbidity in adult life compared with the national statistics. Must *et al.* (1992) conducted a 55-year follow-up study to assess the impact of adolescent obesity on adult mortality and morbidity. The study included 508 adolescents (aged 13-18 years). Overweight subjects were defined as those with a BMI value >75th percentile, whereas lean subjects were those with BMI between 25th-50th percentile of reference. The results revealed that death from coronary heart disease (CHD), atherosclerotic cerebrovascular diseases and colon cancer were increased among men but not women who were classified as obese during adolescence. The relative risk of all-cause mortality was 1.8 (95% CI=1.2-2.7) and for CHD mortality was 2.3 (95% CI =1.4-4.1) in men, who were obese as adolescents, compared to those who were lean. Multivariate analysis showed that the elevation in risk of mortality was independent of adult weight status or smoking, since adjustment for these variables did not significantly affect the observed risks. The same study also showed that in both men and women, rates of occurrence of CHD, atherosclerosis, diabetes, hip fracture and gout are increased in subjects who were overweight in their teens. Except for the risk of diabetes, which became negligible, the risks of these diseases were only slightly reduced after controlling for adult weight.

Childhood and adolescent obesity may influence the risk to adult disease through its effects on the child's blood pressure and lipid profile. Freedman and colleagues (1999a) found that overweight children were more likely than normal weight children to have adverse plasma levels of total cholesterol, LDL-C, TG and HDL-C. Furthermore, Srinivasan *et al.* (1996) observed that the relationship between these metabolic abnormalities and being overweight tends to track with age. It is likely therefore, that CVD risk factors present in the obese child or adolescent will persist into adulthood, thus predisposing to, or causing, adult disease.

3.7.6 Psychosocial consequences

Opinions regarding the social impact of obesity tend to vary among both individuals and societies. In developing societies, obesity may not be associated with widespread psychosocial problems since fatness is still viewed as attractive or as a sign of prestige and affluence. In the western countries, however, psychosocial problems are the most prevalent immediate consequences of childhood and adolescent obesity. Obese children often become targets of discrimination by adults and peers, and they are most likely to be described as lazy, lying, sloppy, ugly and stupid (Must & Strauss, 1999). Cross-sectional and longitudinal studies of obesity in children have demonstrated an inverse relationship between self-esteem and obesity (Klesges *et al.*, 1992; Hill *et al.*, 1994). However, a review by French *et al.* (1995) showed that only 13 of the 25 published cross-sectional studies demonstrated a significant impairment in self-esteem in obese children, with the clearest effect occurring in adolescents (aged 13-18 years). A less consistent pattern was observed in those aged 7-12 years. One possible explanation for this age-related difference in the strength of self-esteem–obesity relationship is that self-image is derived from parental messages in young children whereas in adolescents it is mainly influenced by the culture.

Obesity during adolescence may affect a person's future social performance and economic mobility. In a 7-year follow-up study that included a sample of 10,039 randomly selected American subjects 16 to 24 years of age, Gortmaker *et al.* (1993) found that women who were overweight as teenagers completed less years of advanced education, had a lower household income, were less likely to marry and had double the rate of poverty compared to women who were initially of normal weight. Furthermore, these associations persisted when socio-economic characteristics of the family of origin were controlled for, suggesting that obesity in adolescence was an important cause, rather than a consequence, of socio-economic status.

3.7.7 Other health consequences

Most of the complications of childhood obesity manifest themselves in adult life. However the obese child may suffer from serious morbidities such as hepatitis, gallstone formation, sleep apnea, skeletal disorders and increased intra-cranial pressure (Must & Strauss, 1999). These diseases, however, are largely restricted to the severely obese and are mostly of low prevalence.

3.7.7.1 Hepatic steatosis and gallstone formation

Hepatic steatosis is a condition that is characterised by increased accumulation of fat in the liver. High plasma levels of hepatic enzymes are often seen in obese children and adolescents. Based on increased alanin aminotransferase activity, Tazawa *et al.* (1997), found that 24% of obese children demonstrated evidence of liver steatosis. Both obesity and duration of obesity appear to be important factors. Obesity also increases the risk of gall bladder stone formation (Maclure *et al.*, 1989). This appears to be related to the increased cholesterol saturation of the bile relative to its acid and phospholiplid content, resulting in a greater likelihood of gallstone formation. Gallstones occur less frequently in obese children and adolescents than in adults. Nonetheless, obesity accounts for less than one third of the cases of cholelithiasis observed in children (Must & Strauss, 1999).

3.7.7.2 Sleep apnea

Sleep apnea is another problem that seems to be related to childhood obesity. Marcus *et al.* (1996) evaluated pulmonary complications in a group of 22 obese children and adolescents. Results showed a high prevalence of sleep-disordered breathing, but in the majority of cases it was mild. In a study involving obese children (body weight >150% of ideal weight), Mallory *et al.* (1989) found that about one third of the obese children with a history of breathing difficulties had symptoms consistent with sleep apnea, and approximately one third had abnormal sleep studies.

3.7.7.3 Orthopaedic complications

Obese children are at risk of developing a variety of skeletal disorders. This is because of their soft cartilaginous bones and the presence of unfused growth plates. Blount's disease, which involves bowing of the tibia and femurs and overgrowth of the medial aspect of the tibial metaphysis in response to excess weight bearing, has been found to be associated with obesity in children. The prevalence of Blount's disease is low, but approximately 80% of children with Blount's disease are obese (Dietz *et al.*, 1982). Slipped femoral capital epiphysis is another orthopaedic problem associated with childhood obesity. It occurs as a result of increased weight on the hip joint, which predisposes to dislocation at the femoral growth plate and consequently damage to the femoral head (Must & Strauss, 1999).

3.7.7.4 Pseudo-tumour cerebri

Pseudotumor cerebri is a rare idiopathic disorder of childhood and adolescence. It is characterized by increased intra-cranial pressure leading to headaches, vomiting and blurred vision. It has been suggested that the rise in the intra-abdominal pressure (secondary to excess abdominal fatness), and the resultant increase in cardiac filling pressure, act to increase the resistance to venous return from the brain, thereby causing the intra-cranial pressure to be elevated (Sugerman *et al.*, 1997). Pseudotumor cerebri appears to be associated with obesity in both adults and adolescents and about 30% of adolescents with idiopathic intra-cranial hypertension are obese (Scott *et al.*, 1997).

3.8 CLINICAL ASPECTS OF REGIONAL BODY FAT DISTRIBUTION

In adults, intra-abdominal fat has emerged as the clinically relevant adipose tissue associated with metabolic disturbances leading to diabetes and cardiovascular diseases (Bjorntorp, 1992). Recent evidence suggests that this may also be the case in children (Goran & Gower, 1999). Changes in body composition are known to occur during adolescence, with girls gaining more fat mass and boys gaining more lean mass. In both sexes, fat redistributes from peripheral regions to more central regions, but the abdominal fat accumulation is more pronounced in boys than in girls. The development of obesity at this time may therefore predispose adolescents to increased visceral fat accumulation. Excess abdominal fatness in adolescence has been shown to be associated with a number of cardiovascular risk factors that are known to cluster with obesity (Gillum, 1999; Daniels *et al.*, 1999). Freedman *et al.* (1999b) found that excess accumulation of fat in the abdominal region in children, quantified using WHR or WC was positively related to adverse concentrations of insulin and lipids, independent of weight, height and age. Daniels *et al.* (1999) evaluated the effect of adiposity and fat distribution, assessed using DEXA on CVD risk factors, in a group of 127 children between 9 to 17 years of age. The results revealed that abdominally located fat was significantly and independently related to plasma TG, HDL-C, SBP and left ventricular mass. DEXA and anthropometric measurements (such as WHR and WC), are both indirect measures of IAF. This is because IAF lies within the abdominal cavity and therefore can only be quantified by imaging techniques like MRI. In one study in which this technique was used to examine the relationship between regional fat distribution and lipid profile in obese and non-obese adolescent girls, Caprio *et al.* (1996) documented a positive association between IAF mass and TG and LDL-C levels, and an inverse relationship with HDL-C concentration in obese adolescent girls. IAF has also been shown to be directly correlated with basal insulin and glucose-stimulated insulin levels, and inversely correlated with insulin sensitivity in obese adolescent females (Caprio & Tamborlane, 1999).

The mechanism by which IAF accumulation influences these cardiovascular risk factors is not completely understood. Subjects with greater IAF have lower insulin sensitivity, resulting in higher circulating insulin levels and elevated plasma-free fatty acids concentrations. This insulin resistance enhances lipolysis and transport of free fatty acids to the liver, which in turn may promote hepatic triglycerides and cholesterol synthesis (Caprio & Tamborlane, 1999). Insulin resistance and hyperinsulinemia may also influence the activity of lipoprotein lipase and hepatic lipase, resulting in decreased maturation and increased catabolism of HDL-C.

In summary, childhood and adolescent obesity is a matter of great public health concern. This is because obese children tend to become obese adults, facing increased risk of diabetes and cardiovascular diseases. Parental obesity has been suggested as an important factor contributing to obesity in children and adolescents. However, genes do not directly cause obesity but rather they increase susceptibility to fat gain in subjects exposed to a specific (high-risk) environment. Diet composition, in particular high fat intake, decreased physical activity level and increased TV viewing have all been identified as relevant risk factors of obesity in children and adolescents. In addition the family environment including parents' dietary habits and lifestyle may also play a role in determining children's food preferences and physical activity behaviours, and consequently risk of obesity.

CHAPTER IV: SUBJECTS AND METHODS

In order to determine the true prevalence of obesity among Bahraini adolescents, a sample of 506 intermediate and secondary school students of both sexes and between the ages of 12 to 17 years was selected by multi-stage random sampling technique from the 4 Governorates of Bahrain. The study also investigates the association between obesity among adolescents and various contributing factors such as socio-demographic characteristics, dietary behaviours and physical activity patterns. The relationship between parental obesity and family environment, and adolescents' risk of obesity was examined in a separate case control study (the family environment study), which included a sub-sample of obese and non-obese adolescents and their parents.

Three types of observations/measurements were made:

1. Anthropometric measurements
2. Blood pressure measurements
3. Questionnaires

This chapter provides a detailed description of the study design, setting and procedures, and measurements used in the study.

4.1 STUDY DESIGN

The study was a cross-sectional descriptive / analytical study. It was carried out in the period between September 2000 and March 2001, and included Bahraini male and female intermediate and secondary school students between 12-17 years of age. Multi-stage stratified random sampling technique was used to obtain a population-representative sample of appropriate size, to provide an adequate estimate of the prevalence of obesity among the adolescents. The study also investigated factors contributing to obesity in the participants.

4.1.1 Study setting

The Kingdom of Bahrain is divided into 4 governorates: Capital, Muharraq, Northern Region and Southern Region (see map in Appendix 1B). Each governorate is divided into several areas (residential or others). The setting of the study was the Government's male and female intermediate and secondary schools within the four governorates of Bahrain. School education in Bahrain consists of 12 grades divided into three educational levels, namely primary (grade 1 to 6), intermediate (grade 7, 8 and 9) and secondary (grade 10, 11 and 12). Education in Bahrain is free in all its levels and places are provided for every child reaching the age of six. About 94% of the school-aged children in Bahrain are enrolled in the Governmental schools.

4.1.2 Target population

The target population of the study was Bahraini school students between 12-17 years of age of both sexes. To ensure that the appropriate age groups and various strata of the target population are represented, the sample was selected from all the educational grades within the intermediate and secondary school and from all the 4 geographic areas of Bahrain.

4.1.3 Eligibility criteria

The inclusion criteria comprised all of those Bahraini national male and female students in the Government's intermediate and secondary schools and between the ages of 12 and 17 years.

Exclusion criteria included all students of private schools, all those under the age of 12 years and those over the age of 17 years, as well as non-Bahrainis. Non-Bahrainis were excluded because they are known to have different dietary habits, lifestyles and ethnicity compared to Bahraini natives (Musaiger *et al.*, 2000a). Furthermore most of the non-Bahrainis are expatriates who are temporary residents. They often come looking for better job opportunities and higher income rates. After spending a period of time in the country, and once their objective is fulfilled, they return to their homelands.

4.1.4 Sample size calculation

4.1.4.1 The cross sectional study (prevalence study) sample

The aim of this study was to determine the prevalence of obesity among Bahraini adolescents from a representative population with some precision. Hence, assuming an expected prevalence of 20% and a desire to estimate the prevalence within ±5% of the true estimate and with 95% confidence level, the sample size was calculated using the following equation (Kirkwood, 1988):

$$n = 1.96^2 \times [\, p\,(1 - p) / d^2]$$

where, n = the required sample size

p= the assumed prevalence (0.2)

d= the level of precision (0.05)

Solving the equation, the required sample number (n) = 246

The estimated sample size was re-estimated using EPI INFO version 6. Given a population size of 52,754, expected prevalence of 20% (± 5% as the worst acceptable) and a 95% confidence level, the sample size was found to be 245.

Since the study is based on a multi-stage stratified random sampling technique, the calculated sample size was adjusted (in order to obtain the same precision) by multiplying it by 2 (the design effect factor).

245 × 2 = 490 *plus* 10% (to account for losses) = 539

A sample of 540 Bahraini male and female students aged 12-17 years and representing approximately 1% of the total enrolment for the academic year 2000-2001 (52,754) was included in the study.

4.1.4.2 Case control study (family environment study) sample

A sub-sample of obese and non-obese adolescents chosen from the cross-sectional study, and their parents, were recruited into the case-control (family environment) study. The required sample size was calculated using EPI INFO version 6-statistical package. It was expected that the prevalence of obesity among parents of the non-obese adolescents was about 30%. Thus, to detect differences if parental obesity was associated with a 2.4-fold (OR=2.4) increase in risk of obesity among the children, the number of cases and controls that needed to be studied to give an 85% power of achieving a 5% significance level, was found to be 109 in each group. The sub-sample size estimated for prevalence of parental obesity as well as other variables is presented in Table 4.1.

Table 4.1. Estimation of sub-sample size of the family study

Power	Variable	Exposure in Non-obese	Odds ratio	Sub-sample size
85%	Prevalence of obesity among parents	30%	2.4	109 / 109
85%	≥14 hrs of TV viewing/ week	25%	2.5	106 / 106
85%	Eating breakfast daily	60%	2.5	115 /115

All the obese adolescents (144) identified in the prevalence study (using the WHO (1995) criteria of BMI for age and skinfold for age), and their parents, were enrolled in the case control study. An equal number of sex and age matched non-obese adolescents (≥5th to <85th percentile of BMI for age), and their parents, were also enrolled. Matching of cases began from the extreme ends of the BMI distribution data of the non-obese group for each age category and for each sex.

4.1.5 Sampling

The study was based on a multi-stage random sampling. In order to achieve a representative sample, a hierarchy for the sample frame, which provides access to the sample selection, was designed. The primary level of the hierarchy was divided into units, which comprised the frame for the next level of the hierarchy (Figure 4.1). Bahrain was first divided into 4 geographic areas (which are the same as the fore-mentioned four governorates of Bahrain) and the schools within each geographic area were divided into 4 groups according to the educational level (intermediate and secondary) and the sex of students as follows:

Group I: Boys' secondary schools

Group II: Boys' intermediate schools

Group III: Girls' secondary schools

Group IV: Girls' intermediate schools

Approximately 1% of the total number of students per group per geographic area was recruited in the study. In order to select the sample, the schools in each group were first numbered and then depending on the student population density, 1 or 2 schools were randomly selected from each group within each geographic area. Twenty four schools out of a total of 82 (29%) were included (Appendix 2A and 2B). Using the school's records, a systematic random sample was drawn from each of the 3 grade levels within the selected schools.

Of the original 540 subjects selected from school records, 9 (1.7%) were absent on the day of the data collection, 14 (2.6%) were excluded because their ages, when later verified against school records, were found to be either below or above the study entry criteria (12-17 years) and a further 9 (1.7%) were excluded from the final analysis because of diseases (2 kidney disease, 1 haemophilia and 6 sickle cell anaemia). Only two students (<1%) refused to participate in the study. In total 34 were excluded and five hundred and six adolescent (249 males and 257 females) were enrolled into the study.

The relationship between obesity in the adolescents, parental obesity and family environment was investigated in a separate case control study involving 214 adolescents and their parents. Of the original 288 participants, which included all of the obese cases (144) identified in the cross-sectional study, and an equal number of sex and age-matched non-obese, only 214 adolescents (107 obese and 107 non-obese), and their parents, participated in the case control study. No contact (wrong telephone number, no reply, telephone out of service) could be made with 46 (16%) of the families, 19 families refused to participate (7%), and a further 9 (3%) were

excluded because of inability of the mother to attend the interview because of unavoidable circumstances (illness, delivery, travelling abroad). All interviews were conducted with the mother (primary caregiver), except for three interviews (since the mother was not alive), which were held with the child's father or grandmother.
A diagram showing the adolescent population sample included in the cross-sectional and case control study is presented in Figure 4.2.

Figure 4.1. Schematic presentation of the sampling frame

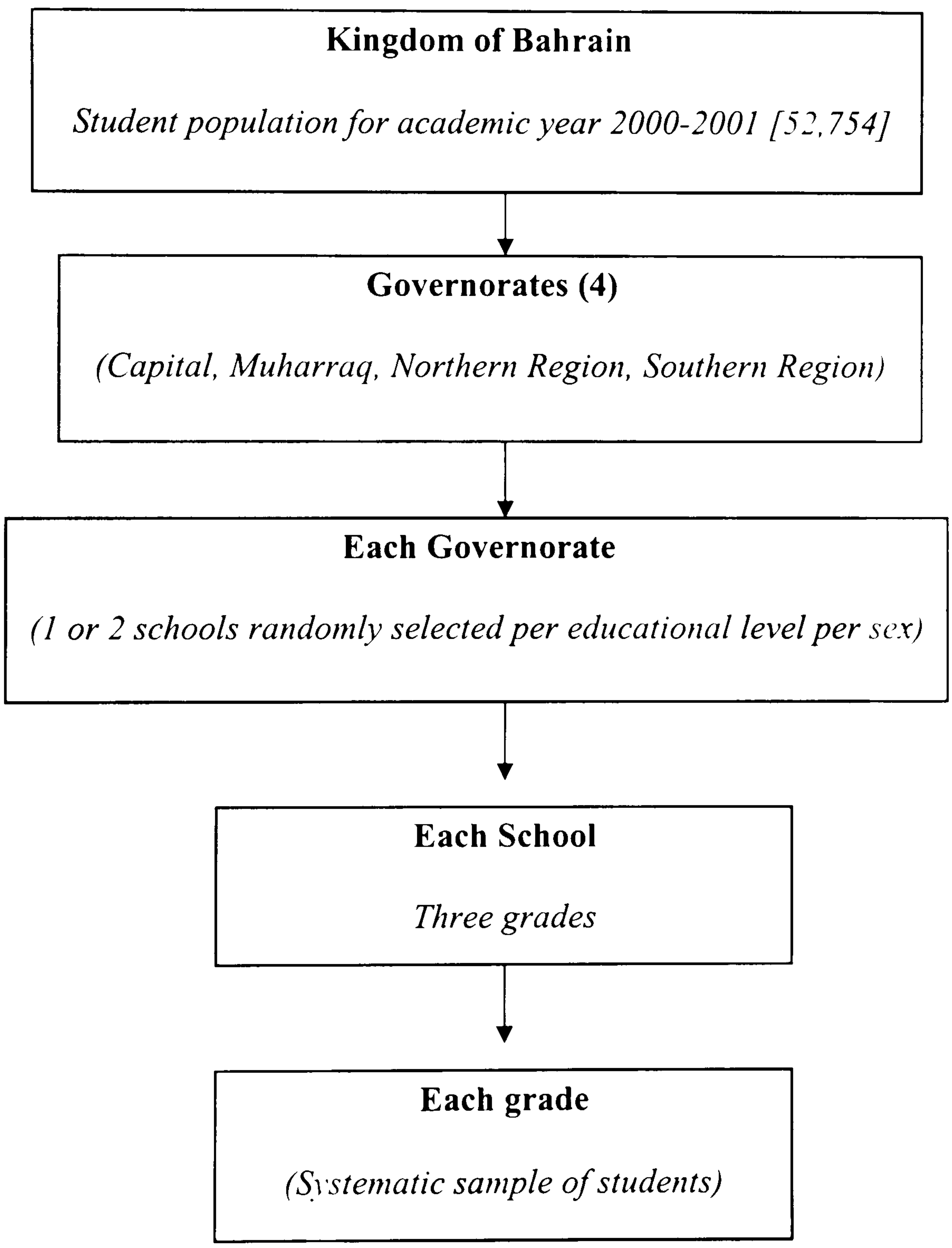


Figure 4.2. Summary diagram showing the study population sample included in the prevalence study and the family environment study

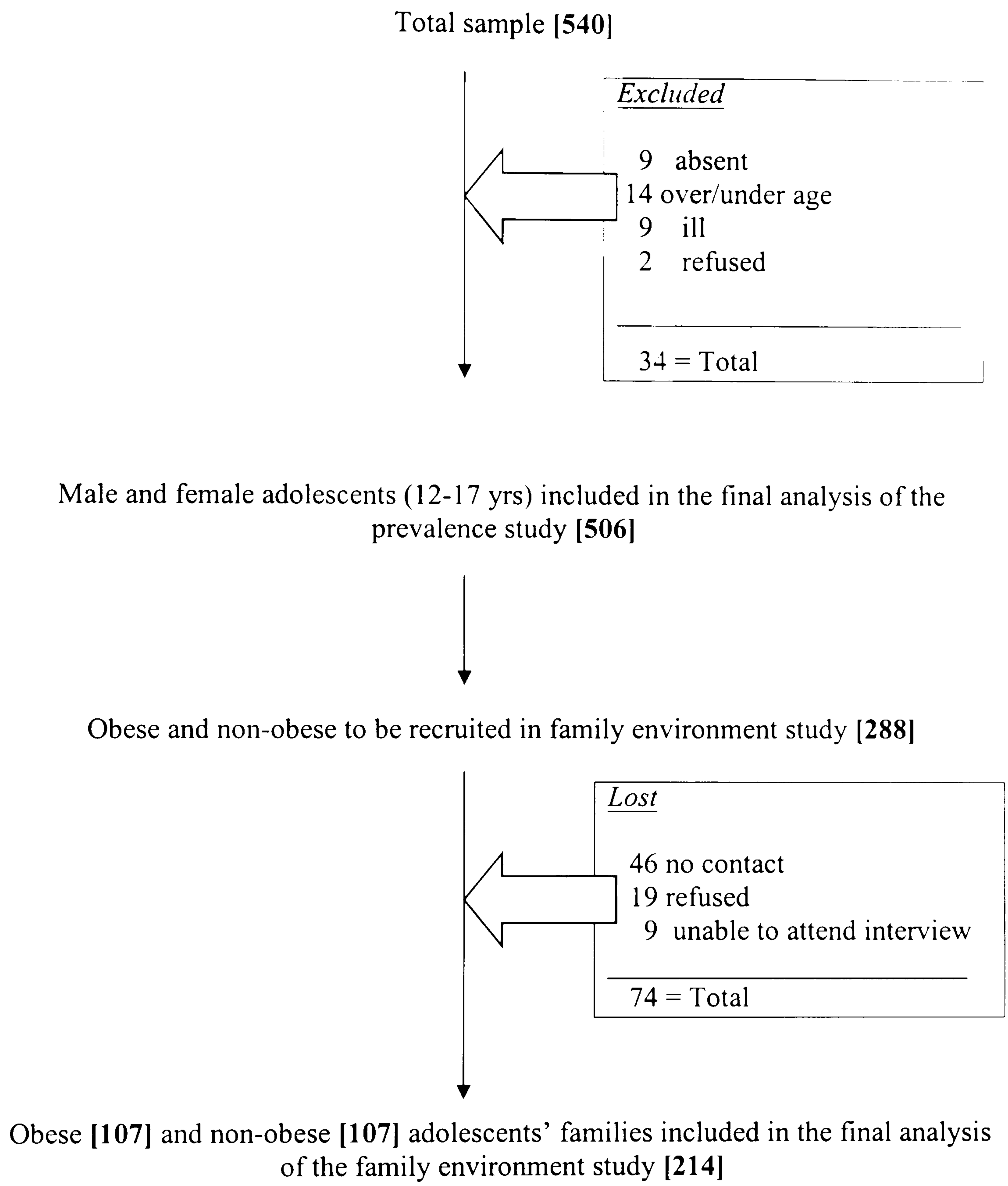


Table 4.2 summarises the percentage distribution of the adolescent Bahraini population by age compared to the study sample. The Bahraini population data, obtained from the Central Statistics Organisation in Bahrain, was based on the latest population census of 2001. Chi square test showed that there was no statistically significant difference between the study sample and the general population in the distribution of adolescents by age (*P*=0.8 in males and *P*=0.9 in females), suggesting that the study sample was representative of the Bahraini 12 to 17-year-old adolescent population.

Table 4.2. Percentage distribution of the adolescent Bahraini population by age compared to the study sample population

Age	Males				Female				Total			
	Census 2001		Sample		Census 2001		Sample		Census 2001		Sample	
	n	%	n	%	n	%	n	%	n	%	n	%
12	5,049	17.6	41	16.5	4,753	17.3	50	19.5	9,802	17.5	91	18.0
13	4,992	17.3	46	18.5	4,791	17.4	43	16.7	9,783	17.4	89	17.6
14	4,799	16.7	48	19.3	4,531	16.5	40	15.6	9,330	16.6	88	17.4
15	4,676	16.3	37	14.9	4,565	16.6	41	16.0	9,241	16.5	78	15.4
16	4,732	16.5	43	17.3	4,473	16.3	40	15.6	9,205	16.4	83	16.4
17	4,464	15.5	34	13.7	4,358	15.9	43	16.7	8,822	15.7	77	15.2
Total	28,712		249		27,471		257		56,183		506	
%	51.1		49.2		48.9		50.8		100.0		100.0	

4.2 DATA COLLECTION

4.2.1 The Prevalence Study

4.2.1.1 Procedure prior to data collection

A brief description of the study and measurements to be carried out, along with a list of schools selected and period of time during which data collection would take place in schools (September 2000 – December 2000) was sent to the Directorate of General and Technical Education (DGTE) at the Ministry of Education. The DGTE in turn contacted the concerned schools' administrations informing them about the study to be conducted and requesting their collaboration with the research team.

Prior to data collection the principal investigator (PI) visited the schools to select the sample and fix appointments for data collection. The sample was chosen using systematic random sampling as follows:

1. The required number of students from each school was divided by 3 to obtain the number of students to be recruited from each grade level (grade 7, 8 and 9 for intermediate schools and grade 10, 11 and 12 for secondary schools).
2. Using the students' name lists, the total number of students in each grade was divided by the required number, to calculate n. The first student was selected randomly and then every nth student on the list was selected until the required number was reached.
3. A replacement sample of 3-5 students was selected from each grade level to substitute for the non-Bahraini students.

In consultation with the school's administration, the PI made an appointment for data collection. She also viewed the room to be allocated for the study and checked whether it had good lighting and adequate space for each measurement station. The selected students were assembled in a classroom for a short meeting. At the meeting, the nationality of the students was verified and those who reported being non-Bahraini were sent back to their classrooms and substituted by the replacement sample. The PI introduced herself and briefly explained the objectives of the study. After reassuring the students regarding the confidentiality and anonymity of the study and that participation was voluntary, they were handed information sheets and consent forms (Appendix 3A and 3B), which needed to be signed by the students and their parents. The students were instructed to bring the signed forms to the school's administration the next day. The PI collected the consent forms on the day of data collection. Finally the PI met with the member of staff (school's secretary or teacher) assigned to accompany the students during the data collection period, handed over a copy of the selected students' names and explained the procedures to be followed on the data collection day in relation to assembling the students in the room provided for the study by the school's administration.

4.2.1.2 Procedure at the school site on data collection day

Data collection was carried out during the period between September to December 2000. The research team arrived at the school site at 7:30 am each morning. Upon arrival the PI checked and calibrated the weighing scale and skinfold calipers. Four measurement stations were set up; these were:

1. Blood pressure (BP) measurement station
2. Weight and height measurement station
3. Skinfold thickness and body circumferences measurement station
4. Questionnaire administration (chairs for students were arranged at the end of the room).

The students were brought into the room in 3 batches (by grade level). The PI explained the details of the study and described various measurements to be taken. She then explained the questionnaire and asked the students to fill it in. While answering the questionnaire, the students were taken one by one to the measurement stations to have their BP, weight and height and body circumference and skinfold measurement taken. Once finished they were instructed to return to their seats and continue filling in the questionnaire.

4.2.1.2.1 Blood pressure measurement

The blood pressure measurement was taken twice after allowing the students to rest quietly for 5 minutes.

4.2.1.2.2 Anthropometric measurements

Anthropometric measurements were performed between 8.00 and 10.00 according to standardized guidelines (Fidanza, 1991). The PI supervised all anthropometric measurements. Students' weight was taken with the school uniform on (which consists of a shirt and trousers for boys and a dress for girls). Students were asked to empty their pockets before stepping onto the scale. Skinfold thickness and body circumference measurements were taken behind a portable screen to ensure the student's privacy and by a person of the same sex as that of the student.

4.2.1.2.3 Administration of questionnaire

The PI supervised the administration of the questionnaire and answered students' questions. Time taken to fill in the questionnaire was 20-25 minutes. The questionnaires were checked for completion by the PI and collected on the same day.

4.2.1.3 Procedure at the school site after data collection

The age of the students was ascertained by checking the date of birth given in the questionnaire against the school's records, which in turn were based on the birth certificate. Students whose ages were found to be below or above 12 to 17 years were excluded from the study.

4.2.2 The Family Environment Study

4.2.2.1 Procedures prior to appointment

Using the phone numbers given in the questionnaires, parents of the sub-sample of obese and non-obese adolescents were contacted by telephone. The PI spoke to the child's mother (or father, if the mother was unavailable). She introduced herself and explained the purpose of the study and its linkage to the school's survey in which the child took part. When the mother agreed to participate in the study, an appointment for home interview was made and the home address was taken. Interviews were carried out during the period between January-March 2001. All interviews were conducted with the child's mother (principal caregiver). In the few cases (3) where the mother was not alive, the father or grandmother was interviewed. The principle investigator and 4 trained and experienced female community health nurses conducted all the interviews.

4.2.2.2 Procedures at the Interview

Participant mothers were interviewed at home by trained female interviewers using a structured pre-tested questionnaire. The interviewer explained the purpose and details of the study and then obtained the mother's signature of the consent form. Verbal probes were used when necessary to elicit more comprehensive information. The time taken to complete the questionnaire was 20-25 minutes.

Weight and height measurements of the mother and father were taken after completion of the interview. In cases where the father was not available at home at the time of interview, his weight and height were taken during a second home visit. Those fathers who still could not be reached were asked to have their weight and height measured in their local health centre or pharmacy. This information was then collected over the telephone.

4.3 MEASUREMENTS AND PROCEDURES

4.3.1 The Prevalence Study

Three types of data/measurements were used in this study

- The questionnaire
- Anthropometric measurements
- Blood pressure measurements

4.3.1.1 The Questionnaire

A structured self-administered questionnaire was used to obtain the following information (see questionnaire in Appendix 4A):

1. Socio-demographic characteristics including, age, sex, parents' occupation and their level of education and number of siblings
2. Dietary behaviours: eating breakfast daily, snacking habits, eating meals with the family, eating meals while watching the TV, frequency intake of fruit, and other common foods
3. Physical activity and inactivity patterns: frequency of playing sport outside school, participation in physical education classes, time spent playing various sports, hours of sleep/day, hours of TV viewing, hours of playing video/computer games
4. Knowledge and attitudes: questions about nutrition, weight gain and statements assessing beliefs about dieting and weight control
5. Body image: perception of self-weight status, perception of parents' and peers' opinion on weight and attitudes toward body weight
6. Health information: personal and family medical history.

Five experts in the fields of nutrition, epidemiology and public health, medical statistics and physical education were recruited to evaluate the questionnaire for content validity. All were informed about the objectives of the study. They were requested to comment on the items included in the questionnaire and their relevance to obesity and the adolescent population. Some of the experts were asked to assess the relevance of questions to the Bahraini population. The questionnaire was modified according to the comments of the reviewers. In order to ensure the clarity of the questions and their appropriateness, the questionnaire was pre-tested twice, initially during the development stage (January 2000) on a sample of 60 intermediate and secondary school students of both sexes, and prior to data collection (August 2000) on a group of 20 adolescent volunteers.

4.3.1.2 Anthropometric measurements:

The anthropometric data included the following measurements and the nutritional indicators derived from them:

1) Weight, 2) Height, 3) Skinfold thickness measurements, 4) Waist circumference, 5) Hip circumference, 6) Mid upper arm circumference.

All anthropometric measurements were performed using standardised procedures and according to the methods described by Fidanza (1991).

4.3.1.2.1 Weight measurement:

Weight was measured to the nearest 0.1 kg using a Seca electronic portable scale (Seca alpha model 770, range 0-200 kg×100g) and while the subject was wearing light clothes and with no footwear. The scale was placed on a hard flat surface and subjects were asked to step into the centre of the platform, stand relaxed but still and look straight ahead. To ensure the accuracy of measurement, the scale was checked for zero-reading before each weighing and calibrated with known weights on the morning of each data collection period. All measurements were taken before recess time to ensure that students had not yet had their morning snack.

4.3.1.2.2 Height measurement:

Students' standing height was measured to the nearest 0.5 centimetre, using a Seca wall-mounted height meter. The student was asked to stand without shoes and socks, back against the wall, heels together, and head in an upright position (Frankfurt plane). To aid the straightening of the spine, the subject was asked to take a deep breath and stand tall. The movable headboard was lowered till it firmly touched the upper part of the subject's head and a direct reading of height was obtained.

4.3.1.2.3 Mid upper arm circumference (MUAC):

Mid upper arm circumference was measured to the nearest 0.1 cm, using a flexible non-stretchable tape (range 0-145cm×1mm, CMS Weighing Equipment Ltd, London, UK). With the subject standing erect and sideways to the measurer, the midpoint of the back of the left upper arm, between the tip of the olecranon process of the ulna and the acromial process of the scapula, was first determined and marked using a felt tip pen. With the subject's arm relaxed and hanging at the side, and palm facing inwards, the tape was then passed around the arm at the marked level so that it was touching the skin but not compressing the tissue.

4.3.1.2.4 Skinfold thickness measurement

Skinfold thickness was measured to the nearest 0.2 mm, on the left side and at the two anatomical locations, namely the triceps and the subscapular. In boys, medial calf skinfold was also taken. Skinfold measurements were made using a Holtain caliper (range 0-40 mm× 0.2 mm, CMS Weighing Equipment Ltd, London, UK.) or a Lange skinfold caliper (range 0-60 mm × 1mm, Cambridge Scientific Industries Inc, USA). The Lange caliper was only used for those with skinfold thickness > 40 mm (i.e. above the measuring range of the Holtain calipers). Three readings were taken at each of the 3 anatomical sites and the average of these 3 readings at each site was recorded as the skinfold thickness. All skinfold measurements were performed by one of two trained observers (one for each sex) whose quality of performance was evaluated prior to and mid way through the study (Appendix 5).

Triceps skinfold (TSKF):

The triceps skinfold thickness was measured at the mid point of the back of the left upper arm, which was located in the same manner previously described for the MUAC. With the arm relaxed at the side of the subject's body, the skinfold parallel to the long axis was picked up away from the underlying muscle and the caliper was applied vertically at the marked level.

Subscapular skinfold (SSKF):

The subscapular skinfold thickness was measured just below and laterally to the inferior angle of the left scapula with the fold in a line running at approximately 45 degrees to the spine along the natural cleavage line of skin.

Medial calf skinfold (CSKF):

This was measured as the thickness of the vertical fold on the medial aspect of the calf. With the subject seated and the knees at 90 degrees, the fold was lifted at the level of the maximal calf circumference on the medial aspect of calf.

4.3.1.2.5 Waist and hip circumference:

Waist and hip circumference measurements were taken to the nearest 0.1 cm using a non-stretchable measuring tape (range 0-145cm ×1mm, CMS Weighing Equipment Ltd, London, UK).

Waist circumference (WC):

Waist circumference was measured with the subject standing erect, abdomen relaxed, arms at the sides and feet together. The measuring tape was placed horizontally at the level of the natural waist, which is the midpoint between the lower margin of the ribs (costal margin) and the superior anterior iliac spine (iliac crest).

Hip circumference (HC):

The subject was asked to stand erect and with arms at the sides and feet together. Hip circumference measurement was recorded as the maximum circumference around the buttocks posteriorly and the symphysis pubis anteriorly.

4.3.1.2.6 The Body Mass Index (BMI):

Determination of obesity was based on the body mass index and skinfold measurement. The BMI, which is the weight in kilograms divided by the height in meters squared, was calculated as follows:

$$BMI = Wt\ (kg) / Ht\ (m^2)$$

4.3.1.2.7 Waist to Hip circumference Ratio (WHR):

Waist to hip circumference ratio (WHR) was used to assess the pattern of fat distribution. WHR was calculated by dividing the waist circumference by the hip circumference.

4.3.1.2.8 Subscapular-Triceps Ratio (STR):

The subscapular-triceps ratio (STR) was used as an index of body fat distribution. It was calculated by dividing the subscapular skinfold thickness by the triceps skinfold thickness.

4.3.1.2.9 Estimation of percent body fat

Body fat percentage was estimated from the sum of skinfold thickness and according to the sex specific equations for children and adolescents (8-18 years) developed by Slaughter *et al.* (1988).

For all boys:

$$\%\ Body\ fat = 0.735\ (TSKF + CSKF) + 1.0$$

For girls with (TSKF + SSKF) ≤ 35 mm:

$$\%\ Body\ fat = 1.33\ (TSKF + SSKF) - 0.013\ (TSKF + SSKF)^2 - 2.5$$

For girls with (TSKF + SSKF) > 35 mm:

$$\% \text{ Body fat} = 0.546\ (TSKF + SSKF) + 9.7$$

Where, CSKF= calf skinfold thickness, TSKF= triceps skinfold thickness, SSKF= subscapular skinfold thickness

4.3.1.2.10 Estimation of fat mass (FM) and fat free mass (FFM):

From percent body fat, total body fat mass (FM) and fat free mass (FFM) were calculated as follows:

$$FM\ (kg) = (\text{percentage body fat} / 100) \times \text{body weight (kg)}$$

$$FFM\ (kg) = \text{body weight (kg)} - \text{body fat mass (kg)}$$

4.3.1.2.11 Mid upper arm muscle circumference (AMC):

The AMC, which represents the circumference of the inner circle of muscle mass surrounding a small central core of bone, was derived from measurements of mid upper arm circumference and triceps skinfold thickness. The AMC was used to assess the total body muscle mass and was calculated using the following equation (Fidanza, 1991):

$$AMC = MUAC - (\pi \times TSKF)$$

Where, MUAC = mid upper arm circumference, TSKF = triceps skinfold thickness

4.3.1.2.12 Mid upper arm muscle area (AMA):

Mid upper arm muscle area is another index of total body muscle mass. It was calculated using the following equation (Fidanza, 1991):

$$AMA = [(MUAC - (\pi \times TSKF))^2 / 4\pi]$$

Where, MUAC = mid upper arm circumference, TSKF = triceps skinfold thickness

4.3.1.2.13 Mid upper arm fat area (AFA):

The mid upper arm fat area, used for estimating total body fat, was calculated from the triceps skinfold thickness and the mid upper arm circumference measurements using the following equation (Himes *et al.*, 1980):

$$AFA = [MUAC \times TSKF/2] - [\pi \times (TSKF)^2 /4]$$

Where, MUAC = mid upper arm circumference, TSKF = triceps skinfold thickness

The age and sex specific reference data of Frisancho (1981) were used to assess mid upper arm fat area (AFA), arm muscle circumference (AMC) and arm muscle area (AMA).

4.3.1.2.14 Determination of weight status

Since BMI and skinfold reference data which are specific for the Arab population were not available, data from the United States' national survey (NHANES-1) were used (Must *et al.*, 1991). The adolescent's weight status was defined according to the following criteria as recommended by the World Health Organisation Expert Committee (WHO, 1995).

Underweight: <5th percentile of BMI for age

Normal weight: ≥5th to <85th percentile of BMI for age

Overweight: ≥ 85th percentile of BMI for age, plus <90th percentile of triceps skinfold for age and <90th percentile of subscapular skinfold for age

Obesity: ≥ 85th percentile of BMI for age, plus ≥90th percentile of triceps skinfold for age and ≥90th percentile of subscapular skinfold for age

In order to facilitate comparison with previous national surveys, the BMI 85th and 95th percentile cut-offs were also used to define overweight and obesity, respectively (Must *et al.*, 1991). In addition, the recently proposed BMI cut-off values of the IOTF (Cole *et al.*, 2000) were used to determine their relative applicability for assessing the degree of overweight and obesity in Bahraini adolescents.

4.3.1.3 Blood pressure:

Systolic and diastolic blood pressure were measured under standardized conditions (Task Force on Blood Pressure Control in Children, 1987) using an Accoson mercury sphygmomanometer of appropriate cuff size (covering 80% to 100% of the arm circumference) and a Littman stethoscope. The same sphygmomanometer was used on all the students. Each student was asked to sit quietly for 5 minutes, to relieve any possible tension, before blood pressure was measured. The student was asked to lay the right arm horizontally on the table and to remove any tight or restrictive clothing from the arm. The blood pressure was then measured with the subject's right arm supported at heart level by the examiner. The cuff was applied making sure that the midpoint was over the position of maximal pulsation of the brachial artery. Systolic blood pressure was initially determined by palpation, then the stethoscope was placed over the brachial artery pulse, proximal and medial to the cubital fossa and below the bottom edge of the cuff. The brachial artery was occluded by inflating the cuff approximately 30 mm Hg above the pressure at which the radial pulse disappeared to palpation. The pressure in the cuff was released slowly, at about 2 mmHg/second. First Korotkoff sound (point at which sounds returned) and Korotkoff phase 5 (disappearance of sounds) were used to define the systolic and diastolic blood pressure, respectively. A qualified female nurse took the blood pressure measurements for all the students. The measurement was repeated after three minutes and the average of the two readings was used in the analysis.

The definition of high blood pressure was based on the report of the Second Task Force on Blood Pressure Control in Children which was recommended by the WHO Expert Committee on Hypertension Control (Table 4.3) (WHO, 1994) as follows:

High BP status: SBP and / or DBP $\geq$95th percentile for age

Normal BP status: SBP and / or DBP <95th percentile for age

Table 4.3. Classification of hypertension in children and adolescents by age

Age (Years)	Systolic and diastolic blood pressure (SBP and DBP), mmHg		
	High to normal (90-94th percentile)	Significant hypertension (95-99th percentile)	Severe hypertension (>99th percentile)
10-12			
SBP	122-125	126-133	≥134
DBP	78-81	82-89	≥90
13-15			
SBP	130-135	136-143	≥144
DBP	80-85	86-91	≥92
16-18			
SBP	136-141	142-149	≥150
DBP	84-91	92-97	≥98

Source: WHO (1994)

4.3.2 The Family Environment Study

4.3.2.1 The Questionnaire

The relationship between adolescents' obesity, parental obesity and the family environment in the sub-sample of obese and non-obese adolescents identified in the cross-sectional study was investigated by using a specially designed interviewer-administered questionnaire (Appendix 4B), which included the following items:

1. Socio-demographic characteristics including parents' age, marital status, parents' level of education and employment, and number of children
2. Information on perinatal factors including child's birth weight and breastfeeding
3. Mother's dietary habits
4. Mother's lifestyle behaviours: physical exercise, hours of TV watching, and availability of domestic help
5. Family history of obesity, diabetes, hypertension and heart disease
6. Mother's influence over child's eating and physical activity behaviours
7. Availability and accessibility of sweets and snacks within the household
8. Mother's perception of, and attitudes to, child's weight status

The questionnaire was developed by reviewing the relevant literature. Many of the questions used in the family study questionnaire (including those related to availability and accessibility of sweets and high calorie snacks within the household, parental influence over child's eating, parent's and child's eating habits and physical activity habits) were adapted from similar items in the Family Eating and Activity Habits Questionnaire, which was developed and validated by Golan and Weizman (1998). Content validity of the questionnaire was determined by a group of 5 experts in the field of nutrition, epidemiology and public health who were asked to assess questions for clarity and appropriateness. A preliminary version of the questionnaire was piloted on a group of 12 volunteer mothers of adolescents prior to data collection (December, 2000). Questions that resulted in ambiguous answers on pilot testing were subsequently reworded to enhance clarity.

4.3.2.2 Anthropometric measurements

Anthropometric measurements included mother's and father's weight and height. Weight and height measurements were performed using the same equipment and procedures described previously with parents wearing light clothes. Obesity in parents was defined according to the WHO expert committee recommendations as a BMI ≥ 30 kg/m^2 (WHO, 2000).

4.4 QUALITY CONTROL

4.4.1 Quality control at the questionnaire level

The accuracy of the collected data was ensured through the following:

1. The questionnaire of the prevalence study was pre-tested twice, during the development stage (January 2000) and prior to data collection (August 2000). The questionnaire of the family environment study was pre-tested on a group of 12 volunteer mothers. This was done in order to ensure the clarity of the questions, their appropriateness and that they could be interpreted correctly.
2. Both questionnaires (questionnaire of the prevalence study and questionnaire of the family environment study) were translated into Arabic and back. A

language expert then checked the translation to ensure that the meaning of the questions was the same in both the Arabic and English versions.

3. The PI supervised the administration of the questionnaire to all students. She also explained the questions to the students and answered their questions.
4. The PI and 4 experienced community health nurses conducted all the home interviews. A one-day workshop was carried out to train the interviewers in use of the family study questionnaire. Mothers' reports of children's birthweight were checked against maternity hospital discharge card or maternity hospital records.

4.4.2 Quality control at the blood pressure measurement level

1. One female qualified nurse took the blood pressure measurements of all the students. Standardized measuring procedures were followed.
2. The sphygmomanometer was checked prior to data collection and then once every two weeks by a qualified technician from the Medical Equipment Department at the Salmaniya Medical Centre in Bahrain.

4.4.3 Quality control at the anthropometric measurement level

The accuracy of the anthropometric data was ensured through the following:

1. The principal investigator conducted a 5-day workshop (early September 2000) in order to thoroughly train the observers in measurement techniques (see workshop handout in Appendix 6).
2. Standardized testing procedures were followed in all measurements.
3. A single observer was used for taking height and weight measurements. Skinfold thickness and body circumference measurements were performed by two observers (one for each sex). All nutritional anthropometric measures were obtained in duplicate, except skinfold thickness, which was measured in triplicate.
4. Instruments were inspected for damage and calibrated daily before use on subjects at each school by the PI. The weighing scale was calibrated against known weights (5 and 10 kg), obtained from the Bahrain Center for Studies and Research. The skinfold calipers were calibrated against a special metal

block of various thickness ranging from 10mm to 40mm (CMS Weighing Equipment Ltd, London, UK.). In addition, pre-set limits were used for repeated measurements in order to safeguard against imprecision. These were 0.2 kg for weight, 1 cm for height, 0.5 cm for circumferences and 2 mm for skinfolds.

In order to check for accuracy of the measurements and to ensure that standardized procedures were being followed, a random sample of 50 students (25 male and 25 female), representing approximately 10% of the study sample, were re-measured by the principal investigator half way through the fieldwork. The repeated measurements (5 pairs) taken by the trained observers and by the principal investigator on the same sample were used to calculate the intra- and inter-observer error of measurement. An initial calculation of the intra- and inter-observer errors was also performed during the training period on a sample of 10 volunteers.
The intra and inter-observer error was estimated by calculating the technical error of measurement (TEM), which is defined as the square root of the sum of squared differences between pairs of measurements obtained by the same or different observers for the same subject divided by twice the number of pairs. TEM was calculated using the following equation (Ulijaszek & Lourie, 1994):

$$TEM = \sqrt{\sum D^2 / 2N}$$

Where, D = difference between measurements, N = number of individuals measured (i.e. number of pairs of measurements).

To get some idea of the acceptability of measurement error, the calculated TEM for height, weight, arm circumference, triceps and subscapular skinfolds were compared with the reference values of Ulijaszek and Lourie, (1994) which are based on data from the NHANES I and II (Table 4.4). Results showed that the calculated TEM values for all the anthropometric measurements were below the maximum acceptable TEM reference values (Appendix 5).

Table 4.4. Reference values for total technical error of measurement (TEM) at two levels of reliability (R=0.99 and R=0.95) for either intra-observer or inter-observer error for anthropometric measurement

Age group (11-17.9 yrs)	Height (cm)	Weight (Kg)	MUAC (cm)	TSKF (mm)	SSKF (mm)
Boys					
Reliability = 0.95	1.69	5.94	0.75	1.45	1.55
Reliability = 0.99	0.76	1.19	0.33	0.65	0.69
Girls					
Reliability = 0.95	1.50	8.66	0.78	1.55	1.74
Reliability = 0.99	0.67	1.73	0.35	0.69	0.78

Source: Ulijaszek & Lourie (1994)

KEY: MUAC= mid upper arm circumference, TSKF= triceps skinfold, SSKF= subscapular skinfold

4.4.4 Quality control at the data management level

1. The PI reviewed all questionnaires for completion immediately after administering them to the students in the school and the recording forms were checked daily for obvious mistakes and for observer's digit preference. The interviewers checked the family environment study's questionnaire immediately after each home interview.
2. All data were entered directly from the pre-coded questionnaires and recording forms (which were stapled to the questionnaire).
3. Double data entry was used to minimise errors in data entry. One person read the coding from the participant's questionnaire/recording form and the principal investigator entered the data into the computer.
4. Computer printouts of the data were reviewed for any information that was out of range. Random questionnaires/recording forms were reviewed for accuracy of data entry.

4.5 DATA MANAGEMENT AND ANALYSIS

4.5.1 Data collection team:

The data collection team consisted of the following persons:

1. The PI who was responsible for the administration of the questionnaire and supervising all measurements and other aspects of the fieldwork
2. A female nurse (Associate Degree in Nursing) who took blood pressure measurement for all the students
3. A female nutritionist (Diploma in Nutrition) who was responsible for taking weight and height for all the students
4. A female nutritionist (MSc in Nutrition) who took skinfold thickness and body circumferences for girls only
5. A male nurse (Associate Degree in Nursing) who took skinfold thickness and body circumferences for boys only.

Data of the family environment study was collected by the PI and four female community health nurses who conducted all the home interviews and took parents' weight and height.

4.5.2 Data entry

The questionnaires were checked for completeness immediately after the end of each data collection session (at the school site or at the participant mother's home). If any data was missing or unlikely, the participant was telephoned at home and requested to supply or verify the information needed. Anthropometric data and blood pressure readings were recorded directly on the recording form, which was stapled to the questionnaire. SPSS statistical software package, version 10 (SPSS Inc., Chicago, IL, USA) was used for data entry and analysis. The pre-coded information present in the data collection instruments was entered directly into the computer. The entered data were verified by checking the computer printouts to detect any information that was out of range. The columns of the data set were sorted in ascending order to check for data entry errors. In addition random questionnaires were reviewed for accuracy of data entry. All errors of data entry were corrected.

4.5.3 Data analysis

4.5.3.1 Prevalence study

The data was first classified into continuous (measurement) data and categorical data. The continuous data, which consisted of the anthropometric and blood pressure measurements, were examined using leaf plots and box plots. Outliers and extreme values were checked against recording forms. Descriptive statistics, including means, medians and standard deviations were then calculated for each anthropometric measurement. Correlation coefficients between BMI and other anthropometric and body composition indicators were determined. Analysis of the anthropometric data was carried out by sex and age. The designated level of statistical significance was $P < 0.05$. The findings were compared with the National Growth Survey of Bahraini School Children (6-18 years) which was carried out in 1986 (Musaiger *et al.*, 1989) and with the United States' Center of Disease Control (CDC) revised growth charts (CDC, 2000).

To estimate the prevalence of weight status, adolescent participants were divided into 4 groups: underweight, normal weight, overweight and obese, according to the WHO recommended criteria of BMI for age and skinfold for age (WHO, 1995). In addition, overweight and obesity were determined using the criteria of Must *et al.* (1991) and the IOTF standard (Cole *et al.*, 2000).

The prevalence study's questionnaire consisted of 6 sections and the total number of questions was 95. Of these only 54 questions were included in the final analysis. In section II, questions related to types of food consumed between meals (snacks) were not included because of the unreliability of data, as many students responded to these questions by listing food items consumed at meals. Section III dealt with knowledge about nutrition and beliefs regarding weight control. It was excluded because of concerns over reliability of some questions. Many of the belief and attitude statements were found not to be relevant to this age group, as they tested behaviours and common misconceptions held by adults. Questions related to type, duration and frequency of exercise were excluded as they yielded unreliable results. Many of the adolescents gave conflicting responses; reporting taking no regular exercise while responding positively to questions related to type and duration of physical exercise and vice versa. In addition many gave exaggerated reports regarding frequency and duration of exercise. Questions related to smoking behaviour were excluded as less than 4% (19 boys and 1 girl) reported smoking.

The primary goal was to determine the association between obesity in the adolescents and various contributing factors. This was studied by means of contingency table analysis. Two Models of BMI for age category were used to classify subjects into 2 groups as follows:

1. Model-I: The proportions of those who were obese (defined as BMI ≥85th percentile) were compared to those who were non-obese (<85th percentile).
2. Model-II: Obese adolescents (defined as BMI ≥95th percentile) were compared to those of normal weight (≥5th to <85th percentile).

Appropriate statistical tests such as chi-square test and chi-square for trend were conducted to determine the statistical association between obesity and the studied variables. Chi-square was considered significant when the p-value was less than 5%. Because of small sample size per cell of contingency tables, questions with 4 response categories (always, frequently, sometimes, rarely) were collapsed into 2 categories (always + frequently = frequently, and sometimes + rarely = rarely). Odds ratios (OR) and 95% confidence interval (CI) were used to quantify the strength of association between obesity risk and each of the other variables. If the 95% CI did not include 1.0, the OR was regarded significant. Logistic regression analysis was used to assess the independent influence of the studied variables on the outcome variable (obesity). Statistical analyses were done by SPSS statistical software package, version 10 (SPSS Inc., Chicago, IL, USA) and EPI INFO version 6 (WHO, Geneva, Switzerland). Graphs were plotted using Prism 3.0 (Graphpad software Inc, USA)

4.5.3.2 Family environment study

Only 58 questions were included in the final analysis of the family study's questionnaire, which consisted of a total of 111 questions. Variables that yielded inconsistent responses in cross-check questions were excluded. These included some of the questions related to the child's eating habits and type and duration of physical exercise taken by the mother. Questions that were found to have low reliability when analysed, such as questions related to the child's physical activity profile were also eliminated. Some of the questions were excluded because of concerns over their suitability to the adolescent's age, as reflected by the inability of many mothers to answer them easily (For example: "Has your child asked for or bought sweets/ snacks he saw advertised on the TV?" and "Have you ever denied your child a particular food as a kind of punishment?").

Because of the relatively small sample size (214), the two sexes were combined in all the analyses of the family environment study. Obese and non-obese adolescents were compared for the studied variables using contingency tables. Odds ratios were used to evaluate strength of association. Multivariate logistic regression models were constructed to assess the joint effects of the combined variables on the risk of adolescent obesity (outcome variable).

4.6 ETHICAL APPROVAL AND INFORMED CONSENT

The study was submitted to the Ministry of Education in Bahrain for reviewing and approval. Ethical approval was also obtained from the Ethics Committee of the London School of Hygiene and Tropical Medicine (Appendix 8).

All adolescents, parents and teachers were thoroughly informed about the purposes and content of the study and a written consent was obtained from the parents (Appendix 3B). The PI ensured that the adolescent participants and their parents understood the nature of the study, the reasons for it being undertaken and the possible benefits to the adolescents' health and the community. All information collected was treated confidentially and was only available to members of the project.

All students who were found to have abnormal blood pressure were referred to the health centre through the school's nurse / administration.

CHAPTER V: RESULTS

This chapter presents the findings from analyses undertaken to determine the prevalence of obesity, its characteristics and determinants in adolescent Bahraini participants. It is organised in six major sections. ***Section one*** describes the socio-demographic and anthropometric characteristics of the study participants (male and female adolescents between 12-17 years of age). ***Section two*** presents the prevalence of obesity in the Bahraini adolescents using three different sets of criteria. The second specific objective of the study is described under ***Section three,*** which investigates the determinants of obesity in this population. Factors examined include socio-economic, dietary and physical activity behaviours. ***Section four*** is based on the findings of the family environment study. It examines the association between obesity in the adolescents and perinatal factors, parental obesity and other factors related to the family environment. ***Section five*** describes the relationship between blood pressure and obesity in the adolescents. The adolescents' perceptions of, and attitudes to, body weight is described in the last section, ***Section six***.

5.1 SOCIO-DEMOGRAPHIC AND OTHER CHARACTERSTICS OF THE ADOLESCENT PARTICIPANTS

5.1.1 Socio-demographic characteristics

Five hundred and six Bahraini adolescents aged 12-17 years participated in the study. A summary of the socio-demographic characteristics of the sample is presented in Table 5.1. Forty nine percent of the participants were males (n=249) and 51% were females (n=257). The distribution of adolescent participants by age ranged from 18% at age 12 years to 15.2% at age 17 years and showed no sex difference (P=0.706).

Table 5.1. Socio-demographic characteristics of Bahraini adolescents

	Total (%)	Sex		P-value
		Males	Females	
Number (%)	506 (100)	249 (49.2)	257 (50.8)	
Age (years)				
12	91 (18.0)	41 (16.5)	50 (19.5)	0.706
13	89 (17.6)	46 (18.5)	43 (16.7)	
14	88 (17.4)	48 (19.3)	40 (15.6)	
15	78 (15.4)	37 (14.9)	41 (16.0)	
16	83 (16.4)	43 (17.3)	40 (15.6)	
17	77 (15.2)	34 (13.7)	43 (16.7)	
Father's occupation				
Working	445 (87.9)	226 (90.8)	219 (85.2)	0.055
Not working	61 (12.1)	23 (9.2)	38 (14.8)	
Mother's occupation				
Working	89 (17.6)	52 (20.9)	37(14.4)	0.055
Not working	417 (82.4)	197 (79.1)	220 (85.6)	
Father's level of education[1]				
Low	59 (11.7)	29 (11.6)	30 (11.7)	0.619
Middle	146 (28.9)	67 (26.9)	79 (30.7)	
High	301 (59.5)	153 (61.4)	148 (57.6)	
Mother's level of education[1]				
Low	109 (21.5)	50 (20.1)	59 (23.0)	0.173
Middle	148 (29.2)	66 (26.5)	82 (31.9)	
High	249 (49.2)	133 (53.4)	116 (45.1)	
Number of siblings				
0-2	85 (16.8)	45 (18.1)	40 (15.6)	0.004
3-5	262 (51.8)	143 (57.4)	119 (46.3)	
6+	159 (31.4)	61 (24.5)	98 (38.1)	

1 Level of education groups: low = illiterate and read & write, middle= primary and intermediate school, high= high school and college

The majority (88%) of the adolescents' fathers were working. Forty one percent were civil servants, 21% were professionals (doctors, lawyers, engineers, accountants and teachers), 13.6% were in manual jobs (skilled and unskilled labourers) and 12.6% were in private businesses (self-employed). The non-working group consisted of 8.5% unemployed and 1.8% retired; in addition, this group included those adolescents whose fathers were dead (1.8%). The percentage of the adolescents' fathers who were working was higher in the boys (91%) than in the girls (85%), but the difference was not statistically significant (*P*=0.055). Most of the teenagers' mothers (82%) were not working (i.e. housewives). In the working group, 8.3% were civil servants, 6.9% were professionals, 1.2% were self-employed and 1.2% were in manual jobs. Three of the adolescents' mothers (0.6%) were dead. Twenty one percent of the boys' mothers were working compared to 14% in the girls (*P*=0.055).

Sixty percent of the fathers and 49% of the mothers had high school or college education and 29% of the mothers and fathers had intermediate or primary school education. Nearly 12% of the fathers and 22% of the mothers were illiterate or could only read and write. There was no statistically significant difference between the boys and girls in parents' level of education (*P*=0.619 for fathers' education and *P*=0.173 for mothers' education). More than half of the participants (52%) came from medium size families with 3 to 5 siblings, 31% from large families with six or more brothers and sisters and 17% came from small families (two siblings or less). The proportion of girls with 6 or more siblings (38%) was greater than that of boys (25%) (*P*=0.004).

5.1.2 Anthropometric characteristics

The anthropometric data of male and female adolescents are summarised in Tables 5.2 and 5.3, respectively. They present the means, standard deviations of the means and medians for height, weight, skinfolds, mid upper arm circumference, waist circumference and hip circumference for each age group. In males, the skinfolds presented are those of the triceps, subscapular and medial calf, whereas in females only the triceps and subscapular skinfolds are presented. Calf skinfold was not taken for the female participants due to cultural constraints, as many girls refused measurement at this site during the pilot study.

Mean values for height and weight increased with age in both sexes, except at age 17 years when height in both boys and girls and weight in girls only dropped slightly from their mean values at age 16 years ($P>0.05$). In both sexes variations in weight were greater than variations of height. In girls, weight was less variable at age 13 and 14 years than other age categories, whereas in boys weight variability appeared to increase with age. At all ages, mean triceps and mean subscapular skinfold were higher in girls than in boys. In general, adolescents' triceps skinfold and subscapular skinfold increased with age, except at age 15 and 16 years in the males and at age 17 years in the females where a decrease occurred. A similar trend was noted in the means of mid upper arm circumference, waist circumference and hip circumference, but the decrease in the males' values was observed at age 15 years only. To assess the prevalence of truncal adiposity among adolescent participants, the sex and age-specific waist circumference cut-offs proposed by Taylor *et al.* (2000) were applied. Twenty nine percent of the boys and 32% of the girls had waist circumference measurements consistent with high trunk fat mass (data not shown).

Tables 5.4 and 5.5 show the means, along with standard deviations and medians of the derived anthropometric and body composition indicators by age group category for the male and female participants, respectively. Parameters studied include body mass index, percent body fat, fat mass, fat free mass, arm fat area, arm muscle circumference and arm muscle area, as well as waist to hip circumference ratio and subscapular to triceps skinfold ratio. BMI showed variations with age and gender. In both sexes BMI was significantly but weakly correlated with age ($r = 0.308$, $P=0.000$ in boys and $r = 0.209$, $P=0.001$ in girls). At all ages, mean BMI was higher in girls than in boys, with the difference reaching the significance level ($P<0.01$) at ages 12 and 15 years only. In girls, mean BMI increased steadily with age till it stabilised at age 16 years. In contrast, boys' BMI showed an increase with age during the early adolescent years, followed by a slight decrease at age 15 years ($P=0.240$), and then it continued to rise thereafter, reaching its highest value at 17 years of age. A similar age trend was seen in the derived indices for body fat (i.e. percent body fat, FM and AFA); with female subjects having greater values than male subjects. The highest mean value of percent body fat occurred at age 17 years in boys (25.8%) and the lowest at age 15 years (18.8%), whereas in girls the highest value was seen at age 16 years (42.2%) and the lowest at age 13 years (33.1%). In boys, variation in fat free mass was characterised by a greater and steadier increase with age than that observed in girls, which tended to drop between 14 and 16 years of age. A marked positive skewness in the distributions of BMI, percent body fat and fat mass was noted, with the degree of skewness increasing with age, suggesting a tendency to increased adiposity in the Bahraini adolescent population.

As expected, mean AMC and mean AMA were greater in the male adolescents than in the females, and they increased with age. Using the sex and age specific reference data of Frisancho (1981) for AMA and AFA, data of the Bahraini adolescents were compared to that of the US children. At almost all ages and in both genders, median values of AMA of the Bahraini teenagers were lower than those of the American children, falling between the 25th and 50th percentile in boys and between the 10th and 25th percentile in girls. In contrast, median values of AFA were higher than that of the reference, fluctuating between the 50th and the 75th percentile in boys, whereas in girls they occurred between the 75th and 90th percentile of the American reference.

Mean values of WHR, which is a measure of regional fat distribution, were always lower than 0.8 in girls and 1.0 in boys, indicating a healthy body fat distribution, according to the criteria of Martinez *et al.* (1994). WHR showed no specific trend with age in the adolescents, but boys had greater mean values than girls at all ages. On the other hand, the STR, which is also a measure of fat distribution and an index of central to peripheral adiposity, showed a sex specific pattern of variation with age. While STR, after the age of 13 years, increased gradually with age in girls, it showed a steep increase in boys, reflecting puberty-induced changes in regional body fat distribution.

Table 5.2. Anthropometric characteristics of adolescent Bahraini males aged 12-17 years, n=249

Anthropometric characteristics	Age (years)					
	12	13	14	15	16	17
	N=41	N=46	N=48	N=37	N=43	N=34
Height (cm)						
Mean (SD)	147.8 (6.9)	155.4 (9.1)	162.2 (8.4)	167.2 (8.4)	170.7 (5.5)	170.1 (6.5)
Median	147.0	156.7	163.6	168.3	171.2	169.5
Weight (kg)						
Mean (SD)	40.7 (10.1)	52.1 (17.6)	59.0 (17.7)	59.1 (17.9)	65.9 (17.2)	70.4 (19.9)
Median	38.0	47.6	54.3	52.9	61.0	64.3
Skinfolds (mm):						
-Triceps						
Mean (SD)	12.2 (7.9)	15.6 (9.4)	15.2 (8.2)	12.2 (8.8)	14.0 (8.2)	18.1 (12.3)
Median	7.9	13.5	12.5	8.6	10.0	14.4
-Subscapular						
Mean (SD)	9.8 (6.6)	13.2 (9.6)	13.4 (8.3)	10.9 (7.4)	12.7 (7.9)	17.1 (13.5)
Median	6.3	9.8	8.5	8.0	8.6	11.9
-Calf						
Mean (SD)	12.2 (8.2)	17.0 (11.2)	16.2 (9.3)	12.0 (8.4)	13.5 (9.1)	15.6 (12.5)
Median	9.1	13.5	12.5	8.8	9.2	12.1
MUAC (cm)						
Mean (SD)	22.6 (3.9)	25.2 (5.4)	27.1 (5.1)	26.1 (5.3)	27.8 (5.3)	29.7 (5.5)
Median	21.0	24.0	27.0	24.5	26.5	29.0
WC (cm)						
Mean (SD)	65.1 (10.9)	72.7 (15.3)	76.1 (15.6)	74.3 (14.4)	77.2 (13.5)	81.3 (16.3)
Median	61.0	69.0	72.0	70.0	73.0	76.2
HC (cm)						
Mean (SD)	77.5 (8.9)	85.7 (13.0)	91.1 (12.1)	89.1 (11.5)	93.2 (12.3)	96.4 (13.8)
Median	74.0	83.0	89.0	85.0	91.0	92.2

Key: *MUAC= Mid upper arm circumference*

WC= Waist circumference

HC= Hip circumference

Table 5.3. Anthropometric characteristics of adolescent Bahraini females aged 12-17 years, n=257

Anthropometric characteristics	Age (years)					
	12 N=50	13 N=43	14 N=40	15 N=41	16 N=40	17 N=43
Height (cm)						
Mean (SD)	151.5 (7.6)	154.5 (6.5)	154.8 (6.1)	156.9 (5.6)	158.2 (5.3)	157.5 (6.1)
Median	153.5	154.1	155.4	157.6	158.0	157.5
Weight (kg)						
Mean (SD)	50.4 (17.2)	52.5 (12.9)	53.1 (14.2)	61.3 (18.9)	63.5 (20.3)	62.1 (18.9)
Median	47.8	50.5	50.5	56.3	58.5	55.3
Skinfolds (mm):						
-Triceps						
Mean (SD)	25.7 (15.0)	25.8 (11.1)	26.7 (12.9)	33.0 (16.8)	33.8 (16.0)	32.3 (15.0)
Median	22.9	24.2	23.0	30.8	33.3	25.5
-Subscapular						
Mean (SD)	19.8 (14.6)	17.7 (8.1)	19.5 (10.3)	25.3 (15.9)	26.5 (15.6)	25.1 (13.9)
Median	14.5	14.7	16.7	19.0	25.3	19.2
MUAC (cm)						
Mean (SD)	25.5 (5.7)	25.9 (4.2)	26.1 (4.8)	28.6 (6.1)	29.3 (6.2)	28.9 (6.1)
Median	24.7	26.0	25.0	27.5	28.2	27.0
WC (cm)						
Mean (SD)	70.2 (12.9)	70.7 (11.5)	71.2 (11.7)	76.2 (13.9)	78.4 (15.5)	77.4 (14.7)
Median	68.0	68.0	68.8	73.0	76.2	73.0
HC (cm)						
Mean (SD)	89.3 (14.0)	90.8 (9.9)	92.3 (11.4)	99.5 (14.8)	100.2 (14.4)	99.9 (13.8)
Median	88.5	89.5	89.0	93.5	97.0	97.0

Key: *MUAC= Mid upper arm circumference*

WC= Waist circumference

HC= Hip circumference

Table 5.4. Mean, SD and median of the derived anthropometric indicators and body composition parameters of adolescent Bahraini males aged 12-17 years, n=249

	Age (years)					
	12	13	14	15	16	17
	N=41	N=46	N=48	N=37	N=43	N=34
BMI (kg/m²)						
Mean (SD)	18.5 (4.0)	21.2 (5.6)	22.3 (5.8)	21.0 (4.9)	22.5 (5.3)	24.4 (7.1)
Median	17.0	19.8	21.0	19.2	21.2	22.1
Percent body fat[1]						
Mean (SD)	19.0 (11.7)	25.0 (14.9)	24.1 (12.6)	18.8 (12.5)	21.3 (12.5)	25.8 (17.6)
Median	13.6	21.5	20.0	13.3	14.8	22.6
Fat mass (kg)						
Mean (SD)	8.7 (8.1)	15.3 (15.0)	16.0 (12.9)	13.0 (14.9)	15.9 (13.6)	21.3 (23.2)
Median	5.1	10.2	11.7	7.8	9.5	13.8
Fat free mass (kg)						
Mean (SD)	31.6 (4.4)	36.7 (6.0)	43.1 (7.2)	46.1 (7.0)	50.0 (6.1)	49.1 (7.9)
Median	31.5	37.2	42.2	44.9	49.4	49.9
AFA (cm²)						
Mean (SD)	13.6 (10.8)	19.4 (15.1)	20.2 (13.6)	16.1 (15.4)	19.4 (14.2)	26.3 (21.7)
Median	7.0	15.1	15.8	10.1	12.5	20.5
AMC (cm)						
Mean (SD)	18.7 (1.8)	20.3 (2.9)	22.3 (2.8)	22.2 (3.1)	23.4 (3.2)	24.0 (2.3)
Median	18.3	20.1	21.9	22.3	23.6	23.7
AMA (cm²)						
Mean (SD)	28.2 (5.7)	33.5 (9.7)	40.5 (10.4)	40.2 (11.5)	44.5 (12.3)	46.5 (9.2)
Median	26.7	32.1	38.3	39.6	44.6	44.6
WHR						
Mean (SD)	0.83 (0.01)	0.84 (0.01)	0.83 (0.01)	0.83 (0.01)	0.82 (0.01)	0.84 (0.01)
Median	0.83	0.83	0.83	0.80	0.81	0.84
STR						
Mean (SD)	0.82 (0.17)	0.86 (0.24)	0.89 (0.22)	0.95 (0.21)	0.95 (0.25)	0.95 (0.24)
Median	0.86	0.84	0.83	0.95	0.94	0.94

1 Calculated using equations of Slaughters *et al*, 1988

Key: AFA= Arm fat area, AMC= arm muscle circumference, AMA= Arm muscle area
WHR= Waist to hip circumference ratio, STR= subscapular to triceps skinfold ratio

Table 5.5. Mean, SD and median of the derived anthropometric indicators and body composition parameters of adolescent Bahraini females aged 12-17 years, n=257

	Age (years)					
	12	13	14	15	16	17
	N=50	N=43	N=40	N=41	N=40	N=43
BMI (kg/m²)						
Mean (SD)	21.5 (6.0)	21.8 (4.4)	22.0 (5.0)	24.7 (7.0)	25.3 (7.7)	25.0 (7.0)
Median	20.5	21.3	20.9	23.3	23.7	23.4
Percent body fat[1]						
Mean (SD)	33.8 (16.6)	33.1 (10.5)	34.6(12.7)	41.3(17.9)	42.2 (17.4)	40.9 (15.7)
Median	29.7	30.2	31.8	37.7	41.2	35.5
Fat mass (kg)						
Mean (SD)	19.5 (16.5)	18.5 (10.2)	19.8(12.2)	28.4(20.6)	30.0 (21.5)	28.0 (19.7)
Median	14.5	14.7	15.5	20.5	25.0	17.5
Fat free mass (kg)						
Mean (SD)	30.8 (5.8)	34.0 (4.3)	33.4 (5.4)	32.8 (4.5)	33.5 (3.7)	34.1 (4.4)
Median	30.5	34.0	33.1	33.7	34.2	34.1
AFA (cm²)						
Mean (SD)	29.7 (21.8)	29.3 (15.6)	30.7 (18.2)	41.4 (26.2)	43.1 (26.4)	40.9 (25.3)
Median	24.4	26.7	24.7	35.7	39.1	27.1
AMC (cm)						
Mean (SD)	17.4 (2.3)	17.7 (1.9)	17.7 (2.4)	18.2 (1.5)	18.7 (2.3)	18.8 (2.4)
Median	17.4	17.9	17.7	17.9	18.4	18.3
AMA (cm²)						
Mean (SD)	24.7 (6.6)	25.4 (5.5)	25.5 (7.1)	26.6 (4.6)	28.2 (7.5)	28.5 (7.6)
Median	24.1	25.4	25.0	25.5	26.8	26.8
WHR						
Mean (SD)	0.78 (0.01)	0.77 (0.01)	0.77 (0.01)	0.76 (0.01)	0.78 (0.01)	0.77 (0.01)
Median	0.78	0.79	0.75	0.76	0.78	0.76
STR						
Mean (SD)	0.75 (0.19)	0.69 (0.16)	0.74 (0.17)	0.75 (0.15)	0.76 (0.17)	0.77 (0.15)
Median	0.77	0.67	0.70	0.76	0.77	0.77

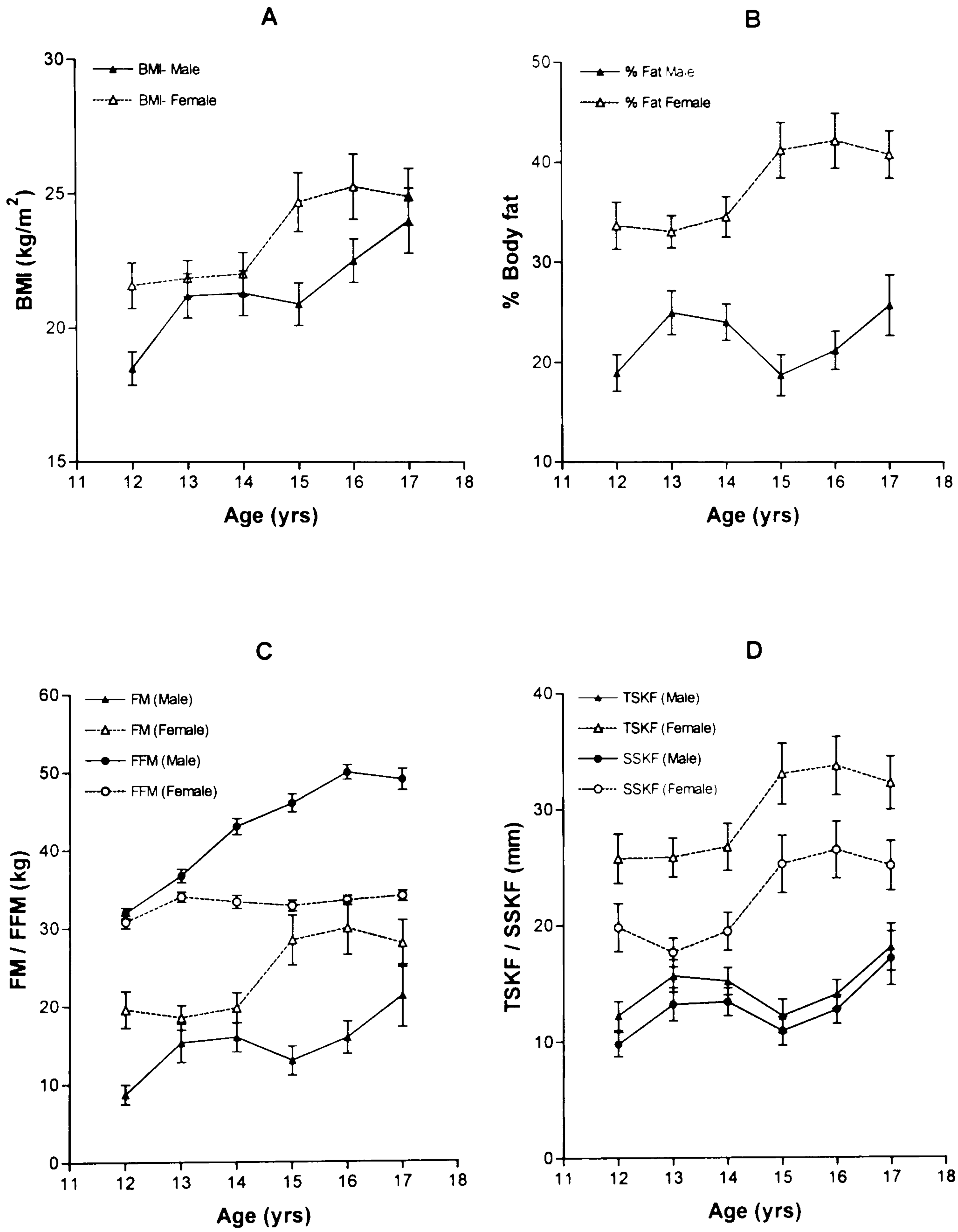
1 Calculated using equations of Slaughters *et al*, 1988

Key: *AFA= Arm fat area, AMC= arm muscle circumference, AMA= Arm muscle area*
WHR= Waist to hip circumference ratio, STR= subscapular to triceps skinfold ratio

To explore the nature of variations in fatness with age in the adolescents, the mean and the standard error of the mean (SEM) of the following pairs of anthropometric indicators were plotted against age (Figure 5.1): BMI and percent body fat, FM and FFM, and TSKF and SSKF. A characteristic sex difference in the variations of these indicators with age was observed. While BMI, percent body fat, FM, TSKF and SSKF increased with age in females, there was a transient decrease in the means of these variables in males at age 15 years which was not statistically significant for BMI (P=0.240) but approached the significance level for percent body fat (P=0.057). FFM, however, continued to increase linearly with age in boys. These trends appear to be related to gender-specific changes in fat and lean tissue accumulation associated with puberty. However since sexual maturational stage was not assessed in these teenagers, and since in this study FM and FFM were derived from percent body fat, which in turn was estimated using equations that depended on skinfold thickness (Slaughter *et al.*, 1988), it is difficult to speculate about the causes of these trends in the body composition of the adolescents.

In summary, a distinct sexual dimorphism in the accumulation of fat during adolescence was observed, even in this cross-sectional study. Changes in BMI, percent body fat and skinfold thickness with age did not follow the same pattern in the Bahraini boys and girls.

Figure 5.1. Cross sectional data showing trends with age of BMI (A), percent body fat (B), FM & FFM (C) and TSKF & SSKF (D) in adolescent Bahraini males and females. Points represent mean ±1 SEM



5.1.2.1 Relationship between BMI and other indicators of fatness

In order to assess the usefulness of BMI as a measure of adiposity in the Bahraini adolescents, the age-adjusted correlation coefficient (r) was used to determine the relation between BMI and other anthropometric indicators. A statistically significant association (P<0.001) was found between BMI and all other anthropometric variables studied, except for the fat free mass in girls (Table 5.6). The linear relationship between BMI and percent body fat was not limited to the obese group, as adolescents with BMI values ≥ 85th and those with <85th percentile of the BMI for age reference (Must *et al.*, 1991) had similar correlations (r =0.84, P< 0.001 and r =0.72, P< 0.001 for boys and r =0.77, P<0.001 and r =0.79, P<0.001 for girls, respectively). This indicates that BMI is a good index of obesity in this population.

Table 5.6. Age-adjusted correlation coefficient (r) of the association between BMI and anthropometric and body composition variables by sex

	Sex	
Anthropometric variables	Males	Females
	r*	r*
Triceps skinfold	0.916	0.897
Subscapular skinfold	0.914	0.905
%Body fat[1]	0.932	0.921
Body fat mass	0.934	0.959
Fat free mass	0.302	0.011 (N.S.)[+]
Mid upper arm circumference	0.959	0.958
Waist circumference	0.956	0.941
Hip circumference	0.931	0.949

1 Calculated using equations of Slaughters *et al.*. (1988)
* All values are significant (P<0.001) unless otherwise specified
\+ Non significant (P>0.05)

5.1.2.2 Comparison of adolescents' BMI data with the US CDC growth chart

Figure 5.2 presents a graphical comparison of the BMI data of the participants with that of the American adolescent population (the revised growth charts of the Centre of Disease Control) (CDC, 2000). For most age categories, median BMI values of the Bahraini teenagers were higher than that of the reference data, especially in girls. Boys' BMI median values fluctuated between the 50th and 75th percentile, except for the ages 12 and 15 years, where the BMI medians fell well below the reference median. In girls, however, BMI medians occurred between the 75th and 85th percentiles of the CDC reference; the only exception was girls in the 14 years age category whose BMI median stayed between the 50th and the 75th percentiles of the American reference.

5.1.2.3 Secular trends of adolescent's BMI in Bahrain

Participants' mean BMI values were compared to corresponding data from previous surveys conducted on Bahraini 12 to 17-year-old adolescents in 1986 (Musaiger & Gregory, 2000) and in 1992 (Musaiger *et al.*, 2000a) (Figure 5.3). There was a clear upward shift in the BMI curves indicating a secular trend of increasing obesity. In both sexes and at all ages, mean BMI values of the participants were higher than those documented in 1986 or in 1992. However, a close agreement between the data of the present study and those of previous studies was observed at ages 14 and 17 years in girls, and at ages 12 and 15 years in boys. In all three studies, there were no consistent trends with age.

In summary, a trend of greater fat accumulation appears to have occurred during the last decade and a half in Bahraini adolescents.

Figure 5.2. BMI median values (filled circles) by age of adolescent Bahraini males and females compared to the US CDC BMI percentile data.

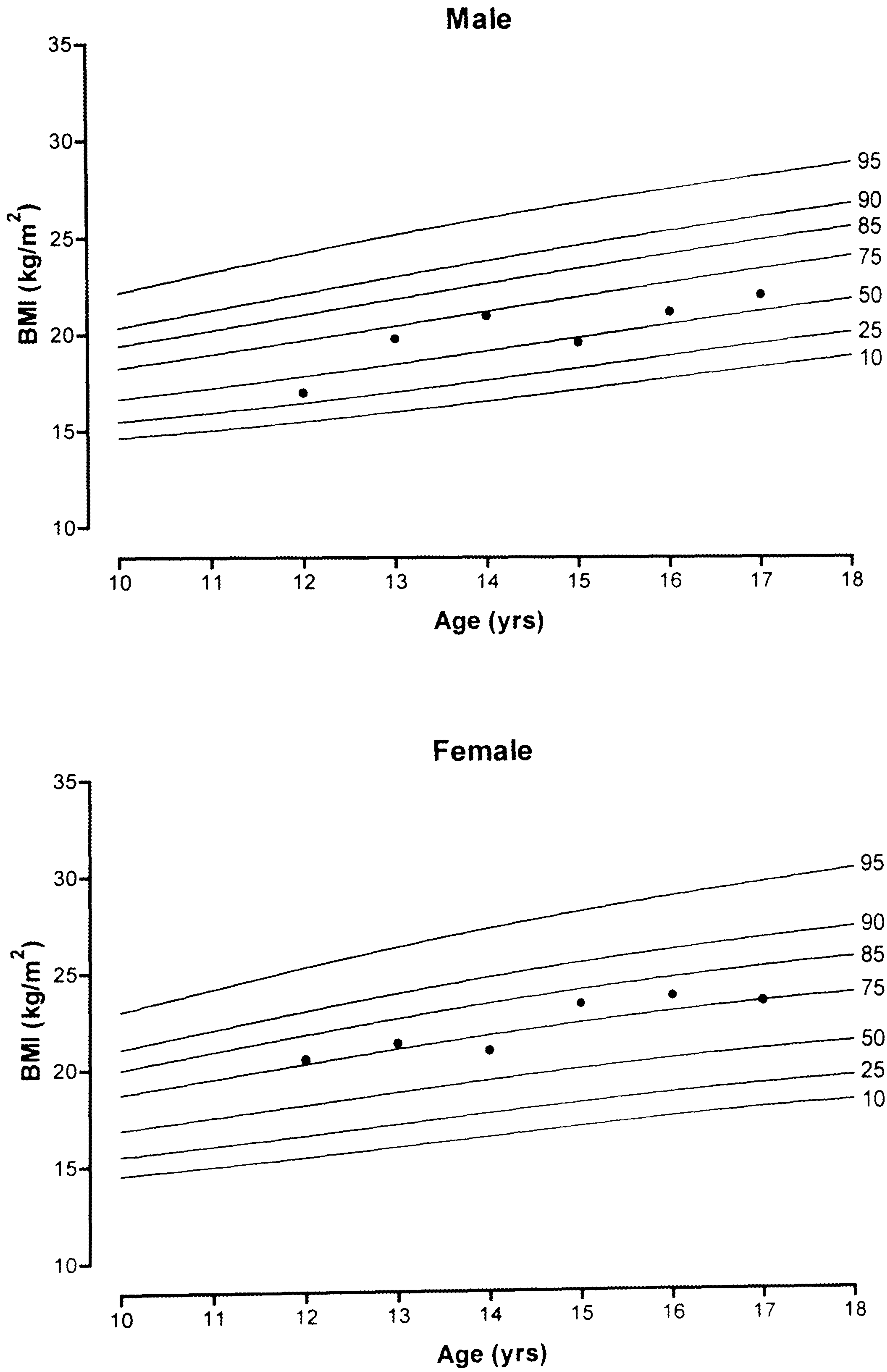
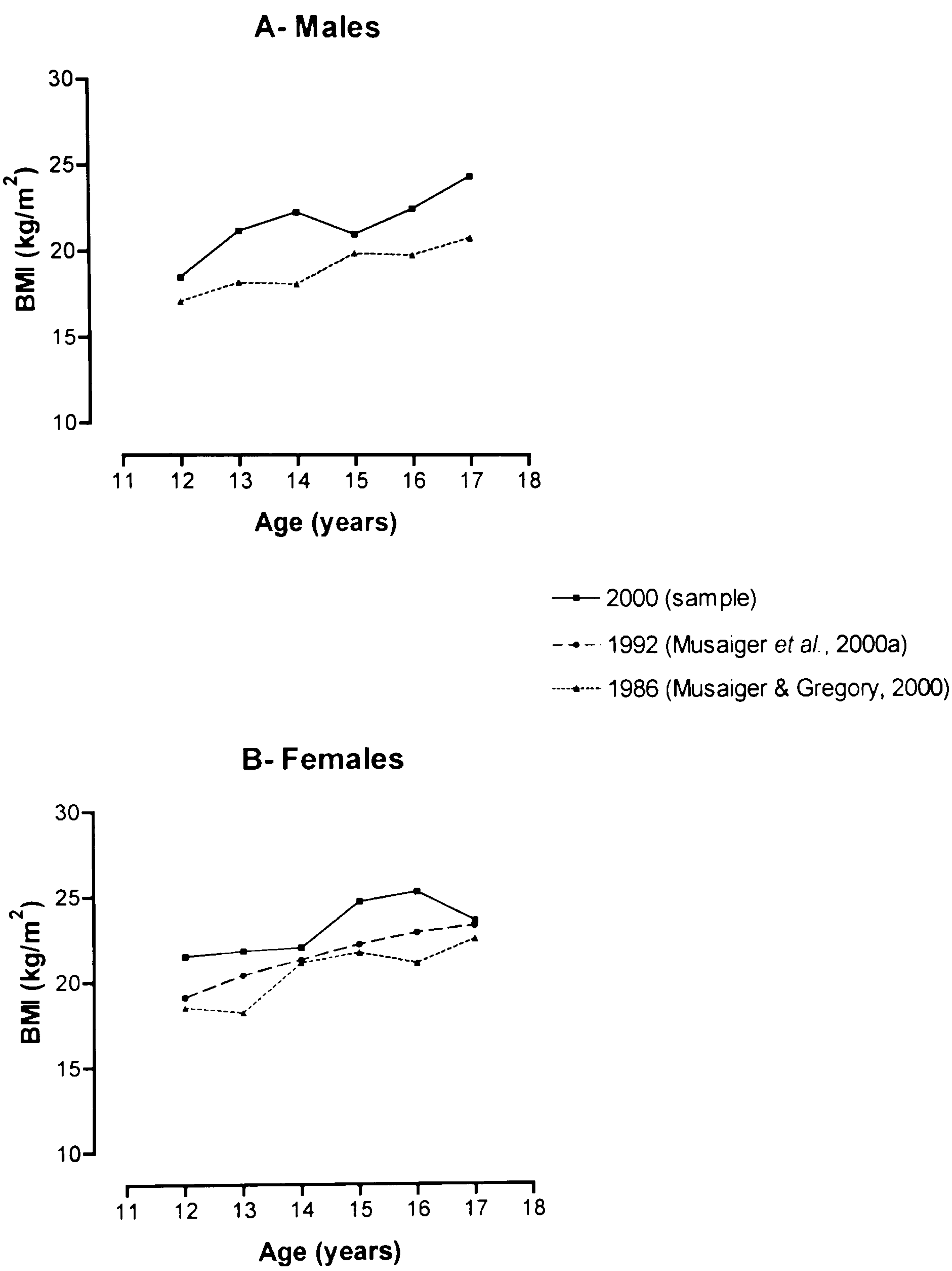


Figure 5.3. Secular trends of adolescent's BMI in Bahrain



5.1.3 Association of fatness with other health-related risk factors

The association between body fatness and other variables considered to be indicative of greater risk to health were investigated in the Bahraini boys and girls. Both body fat, expressed as percentage of body weight, and BMI for age percentile category were employed as adiposity indicators to assess associations with health risk factors which include systolic and diastolic blood pressure status (measured), history of diabetes (reported) and body fat distribution indices (WC, WHR and STR).

5.1.3.1 Association of fatness with other health-related risk factors by percent body fat

The cardiovascular health-related body fat standards for adolescents developed by Williams *et al.* (1992) were used to classify participants according to their level of fatness. According to this standard a body fat percentage at or above 25% in males and 30% in females was indicative of increased risk of CVD. When these cut-off points were applied to the sample, more than half of the girls (60%) and about one third of the boys (32%) were found to have percent body fat at or above the high-risk threshold.

A summary of the associations between percent body fat and high blood pressure and diabetes in the Bahraini adolescents is presented in Table 5.7. Boys and girls with elevated SBP were 2.7 (95% CI=1.3-5.5) and 3.8 (95% CI=1.2-15.7) times, respectively, more likely to be in the high-risk group for percent body fat than those with normal SBP. All of the girls (100%) with high DBP had percent body fat at or above 30%. In boys, however, there was no significant relationship between DBP status and percent body fat (P=0.973). All of the teenagers (100%) who reported having diabetes were in the high-risk group for percent body fat. Table 5.8 shows the association between percent body fat and fat patterning indicators WC, WHR and STR. Percent body fat was positively and strongly associated with WC and WHR. All of the girls (100%) and 85% of the boys in the uppermost tertile of the waist circumference were in the high-risk group for percent body fat. Female and male adolescents in the uppermost tertile of WHR were 7 and 60 times, respectively, more likely to have percent body fat exceeding the sex-specific threshold for fatness than those in the reference group. In both sexes, no significant association between STR and percent body fat was observed (*P*=0.746 in males and *P*=0.163 in females).

5.1.3.2 Association of fatness with other health-related risk factors by BMI for age percentile-category

A similar pattern of associations was observed between BMI percentile category and the studied risk factors (Table 5.9). SBP status in both boys and girls, and DBP status in girls only, were significantly associated with BMI. Boys and girls with elevated SBP were 3 and 10 times, respectively, more likely to have a BMI at or above the 95th percentile than the reference groups. All of the adolescents who reported having diabetes were in the 95th percentile category of BMI. In both sexes, WC and WHR demonstrated a statistically significant association with BMI (*P*<0.001) (Table 5.10). More than three quarters of the boys (77 %) and girls (86%) with WC values in the uppermost tertile were obese (BMI ≥95th percentile). In girls, odds ratios for WHR and STR showed an increasing trend, with the likelihood of obesity in girls in the uppermost tertile of these variables being 18.6 (95%CI=7.2- 48.2) and 8.9 (95%CI=3.7, 21.7), respectively. In boys there was no significant association between STR and BMI (*P*=0.151).

Table 5.7. Association of fatness with high blood pressure and diabetes by percent body fat in Bahraini adolescents.

	Sex												
	Males						Females						
	% Body fat[1]				P-value	Odds ratio (CI)	% Body fat[1]				P-value	Odds ratio (CI)
	≥25		<25				≥30		<30			
	n	(%)	n	(%)			n	(%)	n	(%)		
Systolic BP[2]												
Normal	57	(27.9)	147	(72.1)	0.002	1.0*	133	(57.8)	97	(42.2)	0.011	1.0*
High	23	(51.1)	22	(48.9)		2.7 (1.3, 5.5)	21	(84.0)	4	(16.0)		3.8 (1.2, 15.7)
Diastolic BP[2]												
Normal	73	(32.2)	154	(67.8)	0.973	1.0*	144	(58.8)	101	(41.2)	0.006+	1.0*
High	7	(31.8)	15	(68.2)		0.9 (0.4, 2.7)	10	(100)	-	-		1.7 $ (1.5, 1.9)
Diabetes[3]												
No	78	(31.6)	169	(68.4)	0.10+	1.0*	151	(59.7)	102	(40.3)	0.154+	1.0*
Yes	2	(100)	-	-		3.2 $ (2.6, 3.8)	4	(100)	-	-		1.7 $ (1.5, 1.8)

1 Estimated by equations of Slaughter *et al.* (1988). Classification of % body fat is based on fatness level cut-offs by Williams *et al.* (1992)
2 Classification of systolic and diastolic blood pressure is based on the report of the Second Task Force on Blood Pressure Control in Children (1987)
3. Subjects in whom diabetes was reported
* Reference category
+ Fisher exact
$ Relative risk

Table 5.8. Association of fatness with body fat distribution indices by percent body fat in Bahraini adolescents.

	Sex												
	Males						Females						
	% Body fat[1]				P-value	Odds ratio (CI)	% Body fat[1]				P-value	Odds ratio (CI)
	≥25		<25				≥30		<30			
	n	(%)	n	(%)			n	(%)	n	(%)		
WC tertiles												
1	-	-	84	(100)	0.000	-	7	(8.4)	76	(91.6)	0.000	1.0*
2	13	(15.1)	73	(84.9)			57	(68.7)	26	(31.3)		23.8 (9.7, 58.7)
3	67	(84.8)	12	(15.2)			91	(100)	-	-		-
WHR tertiles												
1	1	(2.4)	40	(97.6)	0.000	1.0*	56	(44.1)	71	(55.9)	0.000	1.0*
2	5	(5.9)	80	(94.1)		2.50 (0.3, 22.1)	60	(71.4)	24	(28.6)		3.2 (1.8, 5.7)
3	74	(60.2)	49	(39.8)		60.4 (8.0, 453)	39	(84.8)	7	(15.2)		7.1 (2.9, 17.0)
STR tertiles												
1	16	(32.0)	34	(68.0)	0.746	1.0*	67	(56.8)	51	(43.2)	0.163	1.0*
2	28	(34.6)	53	(65.4)		1.12 (0.5, 2.4)	53	(60.2)	35	(39.8)		1.2 (0.7, 2.0)
3	36	(30.5)	82	(69.5)		0.9 (0.5, 1.9)	35	(68.6)	16	(31.4)		1.7 (0.8, 3.3)

1 Estimated by equations of Slaughter *et al.* (1988). Classification of % body fat is based on fatness levels cut-offs by Williams *et al.* (1992)
* Reference category

Key: WC = waist circumference, WHR = Waist hip circumference ratio, STR = subscapular to triceps skinfold ratio

Table 5.9. Association of fatness with high blood pressure and diabetes by BMI for age category in Bahraini adolescents

	Sex												
	Males						Females						
	BMI percentile[1]				P-value	Odds ratio (CI)	BMI percentile[1]				P-value	Odds ratio (CI)
	≥95th		<85th				≥95th		<85th			
	n	(%)	n	(%)			n	(%)	n	(%)		
Systolic BP[2]												
Normal	27	(17.4)	128	(82.6)	0.002	1.0*	36	(20.3)	141	(79.7)	0.000	1.0*
High	14	(41.2)	20	(58.8)		3.3 (1.4, 7.9)	16	(72.7)	6	(27.3)		10.4 (3.5, 34.5)
Diastolic BP[2]												
Normal	38	(21.8)	136	(78.2)	1.00⁺	1.0*	45	(23.6)	146	(76.4)	0.000	1.0*
High	3	(20.0)	12	(80.0)		0.9 (0.2, 3.6)	7	(87.5)	1	(12.5)		22.7 (2.7, 1030)
Diabetes[3]												
No	39	(20.9)	148	(79.1)	0.04⁺	1.0*	49	(24.9)	148	(75.1)	0.016⁺	1.0*
Yes	2	(100)	-	-		4.8 $ (3.6, 6.3)	3	(100)	-	-		4.0 $ (3.2, 5.1)

1. Based on Must *et al* BMI for age classification <85th = non-obese, ≥95th percentile= obese . Must *et al.* (1991)
2 Classification of systolic and diastolic blood pressure is based on the report of the Second Task Force on Blood Pressure Control in Children (1987)
3.Subjects in whom diabetes was reported
* Reference category
+ Fisher exact
$ Relative risk

Table 5.10. Association of fatness with body fat distribution indices by BMI for age category in Bahraini adolescents

	Sex											
	Males						Females					
	BMI percentile[1]						BMI percentile[1]					BMI percentile[1]
	≥95th		<85th		P-value	Odds ratio (CI)	≥95th		<85th		P-value	Odds ratio (CI)
	n	(%)	n	(%)			n	(%)	n	(%)		
WC tertiles												
1	-	-	60	(100.0)	0.000	-	-	-	73	(100.0)	0.000	-
2	-	-	76	(100.0)			1	(1.5)	67	(98.5)		
3	41	(77.4)	12	(22.6)			51	(86.4)	8	(13.6)		
WHR tertiles												
1	-	-	33	(100.0)	0.000	-	10	(9.7)	93	(90.3)	0.000	1.0*
2	2	(2.9)	67	(97.1)			18	(29.5)	43	(70.5)		3.9 (1.7, 9.1)
3	39	(44.8)	48	(55.2)			24	(66.7)	12	(33.3)		18.6 (7.2, 48.2)
STR tertiles												
1	6	(14.6)	35	(85.4)	0.151	1.0*	11	(11.6)	84	(88.4)	0.000	1.0*
2	11	(20.4)	43	(79.6)		1.5 (0.5, 4.4)	20	(30.3)	46	(69.7)		3.3 (1.5, 7.5)
3	24	(25.5)	70	(74.5)		2.0 (0.7, 5.3)	21	(53.8)	18	(46.2)		8.9 (3.7, 21.7

1. Based on Must *et al* BMI for age classification <85th = non-obese, ≥95th percentile= obese . Must *et al.* (1991)
* Reference category

Key: *WC= waist circumference, **WHR**= Waist hip circumference ratio, **STR**= subscapular* ***triceps*** *skinfold ratio*

In summary, Bahraini adolescents' anthropometric indicators increased with age. A sexual dimorphism, which appears to be related to differential changes in body composition during puberty, was observed. There was a decrease in the mean values of triceps skinfold, subscapular skinfold, percent fat and fat mass in males, which occurred at age 15 years. In contrast, in the female subjects these anthropometric parameters continued to increase steadily with age. Fat free mass rose with age, with boys showing greater and more progressive increment than girls. In comparison with corresponding data from previous surveys on Bahraini adolescents, the study participants had higher BMI values, indicating a secular trend of increasing obesity in this population. Nearly twice as many girls (60%) as boys (32%) had a percent body fat at or exceeding the high-risk threshold (25 % in males and 30% in females). Elevated levels of SBP, WC and WHR were all significantly associated with increased body fatness as determined by percent body fat or BMI, and in both sexes. DBP and STR were significantly associated with fatness in girls only.

5.2 PREVALENCE OF OVERWEIGHT AND OBESITY

The classification of body weight status for this study is based on the BMI for age and skinfolds for age criteria of the World Health Organisation Expert Committee (WHO, 1995). The United States' BMI reference data published by Must *et al.* (1991) were used, since a local reference is not available.

5.2.1 Prevalence of normal weight

Table 5.11 shows the prevalence of normal weight (BMI for age ≥5th to <85th percentiles) among Bahrain adolescents. More than half of the boys (59%) and the girls (58%) were of normal weight. Most of the normal weight occurred at age 15 years in boys (68%) and age 14 years in girls (70%).

5.2.2 Prevalence of underweight

Approximately three times as many boys as girls had BMI for age values corresponding to the underweight threshold (i.e. below the 5th percentile) (Table 5.12). The prevalence of underweight in the male and female teenagers was 11% and

3.5%, respectively. In males, the highest rate of underweight was observed among the 16 year olds (16.3 %) and the lowest among the 17 year olds (2.9%) whereas in females it was about the same in all age groups except the 12 and 13 year olds in whom underweight was more frequent (6% and 5%, respectively).

Table 5.11. Prevalence of normal weight in the sample

Age (yrs)	Sex			
	Male		Female	
	N	Prevalence of normal weight[1] (%)	N	Prevalence of normal weight[1] (%)
12	41	26 (63.4)	50	26 (52.0)
13	46	26 (56.5)	43	26 (60.5)
14	48	26 (54.2)	40	28 (70.0)
15	37	25 (67.6)	41	21 (51.2)
16	43	24 (55.8)	40	22 (55.0)
17	34	21 (61.8)	43	25 (58.1)
Total	249	148 (59.4)	257	148 (57.6)

1. Normal weight is equivalent to the ≥5th to <85th percentile of BMI for age (WHO, 1995)

Table 5.12. Prevalence of underweight in the sample

Age (yrs)	Sex			
	Male		Female	
	N	Prevalence of underweight[1] (%)	N	Prevalence of underweight[1] (%)
12	41	5 (12.2)	50	3 (6.0)
13	46	5 (10.9)	43	2 (4.7)
14	48	4 (8.3)	40	1 (2.5)
15	37	5 (13.5)	41	1 (2.4)
16	43	7 (16.3)	40	1 (2.5)
17	34	1 (2.9)	43	1 (2.3)
Total	249	27 (10.8)	257	9 (3.5)

1. Underweight is equivalent to <5th percentile of BMI for age (WHO, 1995)

5.2.3 Prevalence of overweight and obesity

Three different sets of criteria/standards were used to define overweight and obesity in Bahraini adolescents. The prevalence of overweight and obesity was firstly determined using both the BMI for age percentiles and the skinfold for age percentiles as recommended by the World Health Organization (WHO, 1995). In addition, overweight and obesity rates were examined using Must *et al's* (1991) criteria, as well as the international BMI cut-off values recently proposed by the IOTF (Cole *et al.*, 2000). This was done in order to compare prevalence estimates obtained from these three sets of reference indicators, as well as to determine their relative applicability for quantifying the degree of fatness in Bahraini adolescents.

5.2.3.1 Prevalence of overweight and obesity using the WHO-recommended criteria of BMI for age and skinfolds for age percentiles

Table 5.13 shows the prevalence of overweight (BMI ≥ 85th percentile and <90th percentile of both TSKF and SSKF) and obesity (BMI ≥85th percentile and ≥ 90th percentile of both TSKF and SSKF) in the Bahraini boys and girls. Among the boys, overweight was more than twice (8%) as prevalent as in girls (3.5%). The overall prevalence of obesity was high, especially in girls. About 21% of the males and 35% of the females were obese. The highest percentage of obesity occurred at age 14 years in boys (29%) and at age 16 years in girls (42.5%). Obesity was lowest at age 15 years in boys (13.5%) and at age 14 years in girls (22.5%).

5.2.3.2 Prevalence of overweight and obesity using Must et al's BMI for age percentile cut-off values

When Must *et al's* (1991) cut-off values for overweight (BMI ≥85th to <95th percentile) were applied, an overall prevalence of overweight that was much higher than that obtained with the WHO criteria was observed. Thirteen percent of the boys and 19% of the girls were overweight (Table 5.14). In contrast, the prevalence of obesity (BMI ≥95th percentile) was considerably lower than that estimated using the WHO criteria, ranging from 16.5 % in boys to 20% in girls.

Table 5.13. Prevalence of overweight and obesity in the sample using the WHO-recommended criteria of BMI for age and skinfolds for age

Age (yrs)	Sex					
	Male			Female		
	N	Overweight[1] (%)	Obesity[2] (%)	N	Overweight[1] (%)	Obesity[2] (%)
12	41	3 (7.3)	7 (17.1)	50	2 (4.0)	19 (38.0)
13	46	4 (8.7)	11 (23.9)	43	1 (2.3)	14 (32.6)
14	48	4 (8.3)	14 (29.2)	40	2 (5.0)	9 (22.5)
15	37	2 (5.4)	5 (13.5)	41	3 (7.3)	16 (39.0)
16	43	4 (9.3)	8 (18.6)	40	0	17 (42.5)
17	34	4 (11.8)	8 (23.5)	43	1 (2.3)	16 (37.2)
Total	249	21 (8.4)	53 (21.3)	257	9 (3.5)	91 (35.4)

1.Overweight is equivalent to ≥85th percentile of BMI for age plus <90th percentile of both TSKF and SSKF (WHO, 1995)
2. Obesity is equivalent to ≥85th percentile of BMI for age plus ≥90th percentile of both TSKF and SSKF (WHO, 1995)

Table 5.14. Prevalence of overweight and obesity in the sample using Must *et al.*'s BMI for age percentile cut-off values

Age (yrs)	Sex					
	Male			Female		
	N	Overweight[1] (%)	Obesity[2] (%)	N	Overweight[1] (%)	Obesity[2] (%)
12	41	8 (19.5)	2 (4.9)	50	11 (22.0)	10 (20.0)
13	46	5 (10.9)	10 (21.7)	43	9 (20.9)	6 (14.0)
14	48	6 (12.5)	12 (25.0)	40	6 (15.0)	5 (12.5)
15	37	3 (8.1)	4 (10.8)	41	7 (17.1)	12 (29.3)
16	43	4 (9.3)	8 (18.6)	40	8 (20.0)	9 (22.5)
17	34	7 (20.6)	5 (14.7)	43	7 (16.3)	10 (23.3)
Total	249	33 (13.3)	41 (16.5)	257	48 (18.7)	52 (20.2)

1. Overweight is equivalent to ≥85 to <95th percentile of BMI for age (Must *et al.*, 1991)
2. Obesity is equivalent to ≥95th percentile of BMI for age (Must *et al.*, 1991)

5.2.3.3 Prevalence of overweight and obesity using the IOTF BMI cut-offs

When the sex and age specific BMI cut-off points of the IOTF (Cole *et al.*, 2000), which are consistent with the accepted cut-off points for adult overweight and obesity (i.e. BMI 25 and 30 kg/m^2, respectively), were used, a lower estimate of the overall prevalence of obesity was found compared to that seen using either the WHO or Must *et al* indicators (Table 5.15). Fifteen percent of the boys and 18% of the girls were obese. In contrast, overall rates of overweight were higher, ranging from15% in males to 24.5 % in females.

Table 5.15. Prevalence of overweight and obesity in the sample using the IOTF BMI cut-off values

Age (yrs)	Sex					
	Male			Female		
	N	Overweight* (%)	Obesity* (%)	N	Overweight* (%)	Obesity* (%)
12	41	8 (19.5)	2 (4.9)	50	14 (28.0)	8 (16.0)
13	46	7 (15.2)	8 (17.4)	43	12 (27.9)	5 (11.6)
14	48	8 (16.7)	10 (20.8)	40	9 (22.5)	5 (12.5)
15	37	3 (8.1)	4 (10.8)	41	9 (22.0)	10 (24.4)
16	43	4 (9.3)	8 (18.6)	40	10 (25.0)	8 (20.0)
17	34	8 (23.5)	5 (14.7)	43	9 (20.9)	10 (23.3)
Total	249	38 (15.3)	37 (14.9)	257	63 (24.5)	46 (17.9)

* Overweight and obesity are defined according to the IOTF standard as BMI ≥age specific BMI cut-offs corresponding to a BMI of 25 kg/m^2 and BMI of 30 kg/m^2, respectively, at age 18 years (Cole *et al.*, 2000)

5.2.4 Comparison of overweight and obesity prevalence estimated by three different sets of criteria/standards

A comparison of the rates of overweight and obesity estimated by three different sets of standards in the male and female adolescents is shown in Table 5.16. In both sexes and at almost all ages, the WHO criteria gave lower estimates of the prevalence of overweight but higher estimates of the prevalence of obesity than the indicators and cut-offs recommended by Must *et al.* (1991) or IOTF (Cole *et al.*, 2000). This appears to be related to the fact that according to the WHO criteria, obesity is defined on the basis of both BMI and skinfold thickness. As a result, when these cut-offs were applied to the data set, overweight participants (≥85th BMI percentile) who also had a high subcutaneous fat store (≥90th percentile of both the TSKF and SSKF) were shifted from the overweight category to the obese category, resulting in lower estimates of overweight and higher estimates of obesity than those determined by the other standards (i.e. Must *et al.* and IOTF).

Relative to Must *et al.*'s standard, the IOTF cut-offs gave greater estimates of overweight prevalence, but lower estimates of obesity prevalence. However, there were a few exceptions when both standards gave identical rates of overweight and obesity. In boys this occurred at ages 12, 15 and 16 years, whereas in girls this was observed only in the obese group at ages 14 and 17 years. Estimates of the overall prevalence of overweight and obesity obtained with the Must *et al.* and the IOTF standards were generally close, with differences generally being <2.3 percentage points for obesity and <5.8 for overweight.

Table 5.16. Prevalence (%) of overweight and obesity among adolescent Bahraini males and females using three sets of criteria/standards

Weight Status	Criteria/standards	Age (years)						Total
		12	13	14	15	16	17	
Males		(n=41)	(n=46)	(n=48)	(n=37)	(n=43)	(n=34)	(n=249)
Overweight	WHO (1995)	7.3	8.7	8.3	5.4	9.3	11.8	8.4
	MUST *et al.* (1991)	19.5	10.9	12.5	8.1	9.3	20.6	13.3
	IOTF- Cole *et al.* (2000)	19.5	15.2	16.7	8.1	9.3	23.5	15.3
Obese	WHO (1995)	17.1	23.9	29.2	13.5	18.6	23.5	21.3
	MUST *et al.* (1991)	4.9	21.7	25.0	10.8	18.6	14.7	16.5
	IOTF- Cole *et al.* (2000)	4.9	17.4	20.8	10.8	18.6	14.7	14.9
Females		(n=50)	(n=43)	(n=40)	(n=41)	(n=40)	(n=43)	(n=257)
Overweight	WHO (1995)	4.0	2.3	5.0	7.3	0.0	2.3	3.5
	MUST *et al.* (1991)	22.0	20.9	15.0	17.1	20.0	16.3	18.7
	IOTF- Cole *et al.* (2000)	28.0	27.9	22.5	22.0	25.0	20.9	24.5
Obese	WHO (1995)	38.0	32.6	22.5	39.0	42.5	37.2	35.4
	MUST *et al.* (1991)	20.0	14.0	12.5	29.3	22.5	23.3	20.2
	IOTF-Cole *et al.* (2000)	16.0	11.6	12.5	24.4	20.0	23.3	17.9

In summary, the prevalence of obesity among Bahraini adolescents between the ages of 12- 17 years varies according to the criteria used to define obesity and overweight. Obesity in the Bahraini teenagers was highest (21% in males and 35% in females) when the WHO recommended criteria were applied, and lowest (15 % in males and 18% in females) when the BMI cut-off values of the IOTF were used.

5.3 DETERMINANTS OF OBESITY IN THE STUDY POPULATION

In this section selected socio-demographic and dietary factors, as well as physical activity and inactivity and other behavioural factors, were examined to determine whether they were associated with risk of obesity in the sample of Bahraini adolescents. Participants were first divided into two groups according to their BMI for age percentile category membership and then contingency tables were constructed for the selected factors. Chi-square statistics and chi-square for trend were used to determine the presence of association between the variables. Risk was estimated using odds ratios and 95% CI.

In order to more clearly contrast characteristics of obese teenagers from those categorised as non-obese or of normal weight, two models of BMI classification (Must *et al.*, 1991) were employed in the assessment of the association between the selected determining factors and the dependent variable (BMI). These models were:

Model-I: The dependent variable, BMI for sex and age, was categorized as:

Non-obese	(BMI<85th percentile)
Obese	(BMI ≥ 85th percentile)

Model-II: The dependent variable, BMI for sex and age, was categorized as:

Normal weight	(BMI ≥ 5th to <85th percentile)
Obese	(BMI ≥ 95th percentile)

Logistic regressions were carried out to examine the independent effects of various contributing factors (socio-demographic, dietary habits, physical activity and inactivity behaviours) and the outcome variable (obesity). Criteria for logistic regression model entry were fixed at a level of significance of *P* value < 0.2 and/or 95% CI that does not include 1.0. This was deemed necessary in order to avoid rejection of variables too early in the regression process. Elimination of variables was done on the basis of least significance using Wald test (in SPSS). In the end only statistically significant variables (i.e. *P*<0.05) were included in the multivariate model.

5.3.1 Socio-demographic factors

Tables 5.17 and 5.18 summarise the relationship between the socio-demographic characteristics of Bahraini adolescent participants and the dependent variable BMI assessed using the above-mentioned two BMI-category models, Model-I and Model-II, respectively. The socio-demographic characteristics studied included, age, father's occupation and mother's occupation, level of education attained by father and mother and the number of siblings. Adolescents were classified into 2 age groups (12-14 years and 15-17 years). Parents' occupational status was categorised as working and not working. Parents' education was defined as low (illiterate and those who could read and write only), middle (primary and intermediate school education) and high (secondary school and college education).

5.3.1.1 Model-I

Nearly 30% and 39% of the boys and girls, respectively, had a BMI value equal to or greater than the 85th percentile of the BMI for sex and age reference and thus were classified as obese (Table 5.17).

5.3.1.1.1 Age

In both males and females, no significant difference was found between age group and obesity status. However, obesity tended to decrease with age in boys whereas in girls it tended to increase with age. In boys, obesity was more prevalent (32%) among the 12-14 year olds than in the 15-17 years age group (27%) (P=0.423). In contrast, older girls had a higher percentage of obesity (43%) compared to the younger group (35%) (P=0.224).

5.3.1.1.2 Parents' occupation

The occupational status of the fathers and mothers showed no statistically significant association with the occurrence of obesity among the adolescents. However, obesity was more prevalent among those boys and girls of working mothers than in those whose mothers were not working (33% Vs. 29% in boys and 43% Vs. 38% in girls). A similar picture was seen with father's occupation, but only in girls. In boys, obesity was higher among those of non-working fathers (35%) than in those whose fathers had jobs (29%).

5.3.1.1.3 Parents' education

While there was no significant association between the level of education attained by the father and obesity in the adolescents, more than half of the obese boys (65%) and obese girls (64%) had fathers who had a high level of education compared to 23% and 26% with middle education and 12% and 10% with a low level of education, for boys and girls respectively. Mother's educational level was significantly associated with the risk of being obese in girls. Of those females whose mothers had a high level of education, 45% were obese compared to 40% and 25% obese among those whose mothers had middle and low education levels, respectively. The odds of obesity among girls who have highly educated mothers were more than two times that of the reference group (OR=2.38, 95%CI=1.2 to 4.8). In boys, the odds of obesity were not significantly associated with the level of mother's education (OR=0.9, 95%CI=0.4 to 1.8).

5.3.1.1.4 Number of siblings

No significant association was found between the number of adolescents' siblings and their obesity status (P=0.061 in boys and P= 0.288 in girls), but obesity in boys tended to decrease with increasing number of siblings, whereas in girls no specific trend was noted.

5.3.1.2 Model-II

The association between the socio-demographic factors and BMI was further explored by categorizing participants into obese and normal weight (Model-II). As in Model-I, there was no statistically significant relationship between obesity and age, parents' occupation, father's education or number of siblings (Table 5.18). Mother's education continued to show a significant and positive association with obesity, but only in girls (OR= 2.43, 95% CI= 1.1 to 5.7, P-value=0.018).

Table 5.17. Crude association of socio-demographic factors and obesity in adolescent Bahraini males and females by obese (≥85th) and non-obese (<85th) categories of BMI for age percentile (Model-I), N=506 (249 males and 257 females)

Age category & Socio-demographic characteristics	Males: BMI for age percentile[1] ≥85th Obese n	(%)	<85th Non-obese n	(%)	P-Value	Odds ratio (95%CI)	Females: BMI for age percentile[1] ≥85th Obese n	(%)	<85th Non-obese n	(%)	P-Value	Odds ratio (95%CI)
Age (yrs)												
12-14	43	(31.9)	92	(68.1)	0.423	1.0*	47	(35.3)	86	(64.7)	0.224	1.0*
15-17	31	(27.2)	83	(72.8)		0.80 (0.44, 1.43)	53	(42.7)	71	(57.3)		1.37 (0.80, 2.33)
Father's occupation												
Not working	8	(34.8)	15	(65.2)	0.577	1.0*	14	(36.8)	24	(63.2)	0.776	1.0*
Working	66	(29.2)	160	(70.8)		1.3 (0.5, 3.4)	86	(39.3)	133	(60.7)		0.9 (0.4, 1.9)
Mother's occupation												
Not working	57	(28.9)	140	(71.1)	0.597	1.0*	84	(38.2)	136	(61.8)	0.559	1.0*
Working	17	(32.7)	35	(67.3)		0.8 (0.4, 1.7)	16	(43.2)	21	(56.8)		0.8 (0.4, 1.7)
Father's education												
Low	9	(31.0)	20	(69.0)	0.471+	1.0*	10	(33.3)	20	(66.7)	0.136+	1.0*
Middle	17	(25.4)	50	(74.6)		0.76 (0.3, 1.9)	26	(32.9)	53	(67.1)		0.98 (0.4, 2.4)
High	48	(31.4)	105	(68.6)		1.02 (0.4, 2.4)	64	(43.2)	84	(56.8)		1.52 (0.7, 3.5)
Mother's education												
Low	15	(30.0)	35	(70.0)	0.640+	1.0*	15	(25.4)	44	(74.6)	0.017+	1.0*
Middle	22	(33.3)	44	(66.7)		1.2 (0.5, 2.6)	33	(40.2)	49	(59.8)		1.98 (1.0, 4.1)
High	37	(27.8)	96	(72.2)		0.9 (0.4, 1.8)	52	(44.8)	64	(55.2)		2.38 (1.2, 4.8)
Number of siblings												
0-3	36	(34.6)	68	(65.4)	0.061+	1.0*	34	(39.5)	52	(60.5)	0.288+	1.0*
4-6	30	(29.4)	72	(70.6)		0.79 (0.4, 1.4)	41	(45.1)	50	(54.9)		1.25 (0.7, 2.3)
7+	8	(18.6)	35	(81.4)		0.43 (0.2, 1.0)	25	(31.3)	55	(68.8)		0.70 (0.4, 1.3)

1 based on BMI for sex and age reference data of Must *et al* (1991).
*Reference category
+ Chi square for trend

Table 5.18. Crude association of socio-demographic factors and obesity in adolescent Bahraini males and females by obese (≥95th) and normal weight (≥5th-<85th) categories of BMI for age percentile (Model-II), N = 389 (189 males and 200 females)

Age category & Socio-demographic characteristics	Males						Females					
	BMI for age percentile[1]						BMI for age percentile[1]					
	≥95th Obese		≥5th -<85th Normal wt		P-Value	Odds ratio (95%CI)	≥95th Obese		≥5th -<85th Normal wt		P-Value	Odds ratio (95%CI)
	n	(%)	n	(%)			n	(%)	n	(%)		
Age (yrs)												
12-14	24	(23.5)	78	(76.5)	0.507	1.0*	21	(20.8)	80	(79.2)	0.090	1.0*
15-17	17	(19.5)	70	(80.5)		0.79(0.37, 1.68)	31	(31.3)	68	(68.7)		1.74 (0.87, 3.47)
Father's occupation												
Not working	36	(20.9)	136	(79.1)	0.536	1.0*	45	(26.3)	126	(73.7)	0.804	1.0*
Working	5	(29.4)	12	(70.6)		1.57 (0.4, 5.2)	7	(24.1)	22	(75.9)		0.89 (0.3, 2.4)
Mother's occupation												
Not working	9	(22.5)	31	(77.5)	0.889	1.0*	11	(35.5)	20	(64.5)	0.190	1.0*
Working	32	(21.5)	117	(78.5)		0.9 (0.4, 2.4)	41	(24.3)	128	(75.7)		0.58 (0.2, 1.4)
Father's education												
Low	3	(14.3)	18	(85.7)	0.539^{+}	1.0*	7	(28.0)	18	(72.0)	0.586^{+}	1.0*
Middle	12	(23.1)	40	(76.9)		1.80 (0.5, 7.2)	13	(20.6)	50	(79.4)		1.67 (0.2, 1.9)
High	26	(22.4)	90	(77.6)		1.73 (0.5, 6.4)	32	(28.6)	80	(71.4)		1.03 (0.4, 2.7)
Mother's education												
Low	5	(15.2)	28	(84.8)	0.567^{+}	1.0*	9	(18.0)	41	(82.0)	0.018^{+}	1.0*
Middle	20	(32.8)	41	(67.2)		2.73 (0.9, 8.1)	12	(19.7)	49	(80.3)		1.12 (0.4, 2.9)
High	16	(16.8)	79	(83.2)		1.13 (0.4, 3.4)	31	(34.8)	58	(65.2)		2.43 (1.1, 5.7)
Number of siblings												
0-3	20	(25.6)	58	(74.4)	0.094^{+}	1.0*	20	(28.6)	50	(71.4)	0.155^{+}	1.0*
4-6	18	(22.5)	62	(77.5)		0.84 (0.4, 1.8)	21	(31.3)	46	(68.7)		1.14 (0.6, 2.4)
7+	3	(9.7)	28	(90.3)		0.31 (0.1, 1.1)	11	(17.5)	52	(82.5)		0.53 (0.2, 1.2)

1 based on BMI for sex and age reference data of Must *et al* (1991)
*Reference category, + Chi square for trend

In summary, there was no significant association between BMI and the socio-demographic factors studied. The only exception was mother's educational attainment, which was strongly and positively associated with obesity in girls, but not in boys.

5.3.2 Dietary habits and behavioural factors

Dietary habits and other eating behaviours, namely eating breakfast daily, snacking habits, frequency of intake of fruit and fast food, eating meals with the family, eating meals while watching TV, distress eating, and behaviour when not hungry at mealtime were examined to assess the strength of the association between these factors and risk of obesity among the adolescent participants using Model-I and Model-II of BMI category.

5.3.2.1 Model-I

Tables 5.19 and 5.20 show the results of the bivariate analysis of the dietary habits and other behavioural factors of the Bahraini adolescents, using BMI category Model-I.

5.3.2.1.1 Eating breakfast daily

Forty nine percent of the boys and 60% of the girls reported that they did not eat breakfast daily. Of those who skipped breakfast, 33% of boys and 42% of girls were classified as obese compared to 26% and 34% in the breakfast eating group, respectively. However, odds ratio showed no significant increase in risk of being obese for those adolescents who skipped breakfast (in boys OR=1.41, 95%CI=0.8 - 2.5 and in girls OR=1.38, 95%CI=0.8 - 2.4).

5.3.2.1.2 Snacking habits

Approximately 21% and 16% of the boys and girls, respectively, reported that they frequently ate snacks late at night. There was a significant association between night-time snacking and obesity in boys (*P*=0.001), but not in girls (*P*=0.842). Boys who frequently snacked at night were about three times more likely to become obese than those who rarely did so (OR=2.80, 95%CI=1.4 to 5.5). A similar trend was observed in relation to afternoon snacking. Obesity was more frequent among boys who snacked in the afternoon (34%) compared to those who did not take afternoon snacks (23%). However, the P-value was only marginally significant (*P*=0.0693). In girls, there was no clear difference between the two groups (*P*=0.786).

5.3.2.1.3 Intake of fruit

No significant association was found between frequency of fruit consumption and the risk of obesity, in both males (*P*=0.513) and females (*P*=0.366). Approximately 27% of the boys and 40% of girls did not eat fruit daily.

5.3.2.1.4 Intake of fast food

Frequency of fast food consumption was assessed with the question "About how many times per week do you eat take-away fast food?". Forty seven percent of the boys and 51% of girls reported eating takeaway fast food more than twice per week. While there was no significant difference between frequency of consumption of fast foods and risk of being obese in boys, girls who ate fast foods twice or more per week had significantly higher odds of obesity than those who reported no intake or once a week (OR = 1.77, 95%CI = 1.03 - 3.04).

5.3.2.1.5 Eating meals with the family

A significant and negative relationship between obesity and frequency of eating meals with family members was observed among girls (*P*<0.001) (Table 5.20). Girls who frequently ate their meals with the family had a significantly lower risk of obesity than those who rarely did so (OR=0.23, 95%CI=0.09 to 0.58). In boys, there was no significant association between eating meals with the family and risk of being obese (*P*=0.352).

5.3.2.1.6 Eating meals while watching TV

More than half of the adolescents (57% in boys and 52% in girls) reported that they often ate their meals while watching TV. Relative to those who rarely ate in front of the TV, girls who frequently ate their meals while watching TV were about two times more likely to be obese (OR=1.80, 95%CI=1.1 to 3.1). In boys, no significant difference was found between the two groups (*P*=0.369).

5.3.2.1.7 Distress eating

Distress eating was ascertained by asking participants how frequently they resorted to eating when upset, angry or in a negative mood. While no association between frequency of distress eating and risk of being obese was observed among boys, girls who tended to find solace in food when upset were 2.8 times (95% CI=1.2- 6.3) more at risk of being obese than those who rarely used food for comfort.

5.3.2.1.8 Behaviour when not hungry at mealtime

When participants were asked the following question, " When it is a mealtime and you are not hungry what would you do? Not eat, eat less or eat the same", more than 60% of the teenagers responded by saying that they tended to eat less or the same. Interestingly, obesity was more prevalent among those who reported not eating compared to those who admitted eating less or the same (34% Vs. 27%, in boys and 50% Vs. 34%, in girls). The relationship between obesity and *behaviour when not hungry at mealtime* was significant in girls (*P*=0.012), but not in boys (*P*=0.293).

5.3.2.2 Model-II

Dietary habits and eating behaviours were further examined using Model-II of BMI categories. In general, a similar trend to that of Model-I was found for all variables studied (Table 5.21 and 5.22). The weak association seen in Model-I between *eating breakfast daily* and obesity status in girls reached a significant level when Model-II was applied (*P*=0.037). Thirty one percent of girls who skipped breakfast were obese compared to 18% among those who did take breakfast. However, the odds ratio did not show a significant increase in the risk of obesity (OR=2.1, 95%CI= 1.0 to 4.6).

Table 5.19. Crude association of dietary habits & behavioural factors and obesity in adolescent Bahraini males and females by obese (≥85th) and non-obese (<85th) categories of BMI for age percentile (Model-I), N = 506 (249 males and 257 females)

Variable	Males						Females					
	BMI for age percentile[1]						BMI for age percentile[1]					
	≥85th **Obese**		<85th **Non-obese**		P-Value	Odds ratio (95%CI)	≥85th **Obese**		<85th **Non-obese**		P-Value	Odds ratio (95%CI)
	n	(%)	n	(%)			n	(%)	n	(%)		
Eating breakfast daily												
Yes	33	(26.2)	93	(73.8)	0.217	1.0*	35	(34.3)	67	(65.7)	0.220	1.0*
No[2]	41	(33.3)	82	(66.7)		1.41 (0.8, 2.5)	65	(41.9)	90	(58.1)		1.38 (0.8, 2.4)
Snacking habits:												
-Late night snacking												
Rarely	49	(24.9)	148	(75.1)	0.001	1.0*	85	(39.2)	132	(60.8)	0.842	1.0*
Frequently	25	(48.1)	27	(51.9)		2.80 (1.4, 5.5)	15	(37.5)	25	(62.5)		0.93 (0.4, 2.0)
-Afternoon snacking												
Rarely	23	(23.2)	76	(76.8)	0.069	1.0*	27	(40.3)	40	(59.7)	0.786	1.0*
Frequently	51	(34.0)	99	(66.0)		1.70 (0.5, 1.7)	73	(38.4)	117	(61.6)		0.92 (0.5, 1.7)
Intake of fruit												
Daily	52	(28.6)	130	(71.4)	0.513	1.0*	63	(41.2)	90	(58.8)	0.366	1.0*
Occasionally	22	(32.8)	45	(67.2)		1.22 (0.6, 2.3)	37	(35.6)	67	(64.4)		0.79 (0.5, 1.4)
Intake of fast foods (time/week)												
<2	44	(33.1)	89	(66.9)	0.213	1.0*	40	(32.0)	85	(68.0)	0.027	1.0*
≥2	30	(25.9)	86	(74.1)		0.71 (0.4, 1.3)	60	(45.5)	72	(54.5)		1.77 (1.03, 3.04)

1 based on BMI for sex and age reference data of Must *et al*, (1991)
2 sometimes or rarely
*Reference category

Table 5.20. Crude association of dietary habits & behavioural factors and obesity in adolescent Bahraini males and females by obese (≥85th) and non-obese (<85th) categories of BMI for age percentile (Model-I), N = 506 (249 males and 257 females)

Variable	Males						Females					
	BMI for age percentile[1]						BMI for age percentile[1]					
	≥85th Obese		<85th Non-obese		P-Value	Odds ratio (95%CI)	≥85th Obese		<85th Non-obese		P-Value	Odds ratio (95%CI)
	n	(%)	n	(%)			n	(%)	n	(%)		
Eating meals with the family												
Rarely	7	(22.6)	24	(77.4)	0.352	1.0*	19	(70.4)	8	(29.6)	0.000	1.0*
Frequently	67	(30.7)	151	(69.3)		1.52 (0.59- 4.10)	81	(35.2)	149	(64.8)		0.23 (0.09 – 0.58)
Eating meals while watching TV												
Rarely	35	(32.7)	72	(67.3)	0.369	1.0*	39	(31.7)	84	(68.3)	0.023	1.0*
Frequently	39	(27.5)	103	(72.5)		0.78 (0.4, 1.4)	61	(45.5)	73	(54.5)		1.80 (1.1, 3.1)
Distress eating[2]												
Rarely	66	(29.6)	157	(70.4)	0.901	1.0*	80	(35.7)	144	(64.3)	0.006	1.0*
Frequently	8	(30.8)	18	(69.2)		1.06 (0.4, 2.7)	20	(60.6)	13	(39.4)		2.77 (1.2, 6.3)
Behaviour when not hungry at mealtime												
Not eat	31	(33.7)	61	(66.3)	0.293	1.0*	41	(50.0)	41	(50.0)	0.012	1.0*
Eat same or less	43	(27.4)	114	(72.6)		0.74 (0.4, 1.4)	59	(33.7)	116	(66.3)		0.51 (0.3, 0.9)

1 based on BMI for sex and age reference data of Must *et al*, (1991)
2. Eating when upset, angry or in negative mood
*Reference category

In males, *afternoon snacking* continued to be significantly related to obesity (P=0.023), whereas *snacking late at night*, was no longer significant (P=0.227). The risk for being obese was 2.4 (95% CI= 1.1 - 5.5) times more for boys who frequently took afternoon snacks compared to those who rarely did so. In girls, neither *afternoon snacking* nor *late night snacking* showed any significant difference between the obese and normal weight group (P=0.567) (P=0.833), respectively. Girls who reported eating fast foods twice or more per week had a significantly greater risk of being obese than those who reported low levels of intake (less than twice per week) (OR=2.56, 95%CI=1.3 - 5.3). In boys, there was no significant difference between the two groups (P=0.213). As in Model-I, no significant difference was found in relation to the intake of fruit in both boys (P=0.644) and girls (P=0.547). Among girls, *eating meals with the family* was associated with a significant reduction in risk of obesity (OR=0.19, 95%CI= 0.06 - 0.56), whereas *eating meals while watching TV* and *distress eating* were associated with 2.2 and 3.8 times greater likelihood of being obese, respectively, compared to the reference group (Table 5.22).

In summary, adolescents who practice eating behaviours which are generally considered "unhealthy", have increased risk of being obese. A sex difference was observed in the relationship between risk of obesity and most of the dietary and behavioural variables studied. Girls who skip breakfast, consume fast foods more than twice per week, eat their meals while watching TV and practice distress eating have a significantly greater risk of development of obesity compared to those who do not demonstrate these behaviours. *Eating meals with the family* was found to have a protective effect in girls. In males, frequent snacking was the only variable among the dietary and behavioural factors that appeared to be related to an increased risk of obesity.

Table 5.21. Crude association of dietary habits & behavioural factors and obesity in adolescent Bahraini males and females by obese (≥95th) and normal weight (≥5th-<85th) categories of BMI for age (Model-II), N = 389 (189 males and 200 females)

Variable	Males						Females					
	BMI for age percentile[1]						BMI for age percentile[1]					
	≥95th **Obese**		≥5th -<85th **Normal wt**		P-Value	Odds ratio (95%CI)	≥95th **Obese**		≥5th -<85th **Normal wt**		P-Value	Odds ratio (95%CI)
	n	(%)	n	(%)			n	(%)	n	(%)		
Eating breakfast daily												
Yes	22	(21.2)	82	(78.8)	0.842	1.0*	13	(17.6)	61	(82.4)	0.037	1.0*
No[2]	19	(22.4)	66	(77.6)		1.07 (0.5, 2.3)	39	(31.0)	87	(69.0)		2.10 (1.0, 4.6)
Snacking habits:												
-Late night **snacking**												
Rarely	31	(20.0)	124	(80.0)	0.227	1.0*	44	(25.7)	127	(74.3)	0.833	1.0*
Frequently	10	(29.4)	24	(70.6)		1.67 (0.7, 4.1)	8	(27.6)	21	(72.4)		1.1 (0.4, 2.9)
-Afternoon snacking												
Rarely	11	(13.8)	69	(86.3)	0.023	1.0*	12	(23.1)	40	(76.9)	0.576	1.0*
Frequently	30	(27.5)	79	(72.5)		2.38 (1.1, 5.5)	40	(27.0)	108	(73.0)		1.23 (0.6, 2.8)
Intake of fruits												
Daily	29	(20.9)	110	(79.1)	0.644	1.0*	32	(27.6)	84	(72.4)	0.547	1.0*
Occasionally	12	(24.0)	38	(76.0)		1.20 (0.5, 2.7)	20	(23.8)	64	(76.2)		0.82 (0.4, 1.6)
Intake of fast foods (time week)												
<2	25	(25.3)	74	(74.7	0.213	1.0*	17	(17.2)	82	(82.8)	0.004	1.0*
>2	16	(17.8)	74	(82.2)		0.64 (0.3, 1.4)	35	(34.7)	66	(65.3)		2.56 (1.3, 5.3)

1 based on BMI for sex and age reference data of Must *et al.* (1991)
2 sometimes or rarely
*Reference category

Table 5.22. Crude association of dietary habits & behavioural factors and obesity in adolescent Bahraini males and females by obese (≥95th) and normal weight (≥5th-<85th) categories of BMI for age (Model-II), N= 389 (189 males and 200 females)

Variable	Males: BMI for age percentile[1] ≥95th Obese n	(%)	≥5th -<85th Normal wt n	(%)	P-Value	Odds ratio (95%CI)	Females: BMI for age percentile[1] ≥95th Obese n	(%)	≥5th -<85th Normal wt n	(%)	P-Value	Odds ratio (95%CI)
Eating meals with family												
Rarely	4	(15.4)	22	(84.6)	0.400	1.0*	11	(61.1)	7	(38.9)	0.000	1.0*
Frequently	37	(22.7)	126	(77.3)		1.62 (0.50, 6.84)	41	(22.5)	141	(77.5)		0.19 (0.06, 0.56)
Eating meals while watching TV												
Rarely	21	(27.3)	56	(72.7)	0.122	1.0*	18	(18.4)	80	(81.6)	0.015	1.0*
Frequently	20	(17.9)	92	(82.1)		0.58 (0.3, 1.2)	34	(33.3)	68	(66.7)		2.22 (1.1, 4.5)
Distress eating[2]												
Rarely	37	(22.0)	131	(78.0)	1.00	1.0*	39	(22.3)	136	(77.7)	0.001	1.0*
Frequently	4	(19.0)	17	(81.0)		0.83 (0.2, 2.8)	13	(52.0)	12	(48.0)		3.78 (1.5, 9.7)
Behaviour when not hungry at mealtime												
Not eat	21	(27.6)	55	(72.4)	0.104	1.0*	24	(37.5)	40	(62.5)	0.010	1.0*
Eat same or less	20	(17.7)	93	(82.3)		0.56 (0.3, 1.2)	28	(20.6)	108	(79.4)		0.43 (0.2, 0.9)

1 based on BMI for sex and age reference data of Must *et al*, (1991)
2 Eating when upset, angry or in negative mood
*Reference category

5.3.2.3 *Frequency of intake of some common foods*

In order to determine whether frequency of intake of food was associated with increased risk of obesity among the adolescents, a short food frequency questionnaire that included 18 items, representative of some common foods and snacks usually appreciated by teenagers (see questionnaire in Appendix 4A), was administered to the participants. The results of the analysis of the food frequency questionnaire are presented in Appendix 7.

In general there appeared to be no association between the frequency of consumption of foods and the occurrence of obesity among the adolescents. Of the eighteen food items analysed only fruit juice, nuts, sweets and puffed corn showed significant associations with obesity. Of the boys who reported a high intake of fruit juice (4 times per week or more), 26% were obese compared to 38% among the low intake group (less than 4 times per week) (P=0.049), but odds ratios showed no significant decrease in the risk of obesity (OR=0.57, 95%CI=0.31-1.04).

The consumption of sweets, puffed corn and nuts showed the opposite picture. It was rather unexpected to find that boys with a high intake of sweets had significantly lower risk of being obese than those with a low intake (OR=0.45, 95%CI=0.25-0.78). Similarly, the prevalence of obesity was significantly lower among girls with high intakes of puffed corn (P=0.012) and nuts (P=0.046) than among those with low intakes, but odds ratio showed significant reduction in risk only for intake of puffed corn (OR=0.51, 95%CI=0.29-0.89).

5.3.3 Behaviours related to physical activity and inactivity

Physical activity and inactivity behaviours were assessed in the adolescents to determine their association with the risk of being obese. Behaviours related to physical activity were ascertained with the questions: "How do you go to school? walking, cycling or by car/bus" and " How often do you play sport outside school? seldom, sometimes, frequently" and "Do you participate in school's physical education classes (PE)? always, sometimes, rarely". Inactivity level was determined by asking participants about hours per day spent watching TV and time spent in other sedentary activities, such as doing homework, reading and playing video computer games (see questionnaire in Appendix 4A).

5.3.3.1 Model-I

The associations between physical activity and inactivity behaviours of Bahraini adolescents and risk of obesity using Model-I of BMI category are presented in Table 5.23.

5.3.3.1.1 Walking/cycling to school

Only 20% of the male and 11% of the female participants reported that they walked or cycled to school daily. Of those boys and girls who reported walking or cycling to school, 16% and 30% were obese compared to 33% and 40% among those who travelled to school by other means, respectively. Boys who walked or cycled to school had a significantly lower risk of obesity than those who travelled to school by car or bus (OR=0.38, 95%CI=0.16 - 0.91). A similar trend was seen among girls but the association was not statistically significant (P=0.295).

5.3.3.1.2 Playing sport outside school

Forty four percent and 71% of the male and female teenagers, respectively, reported that they seldom played any kind of sport other than school PE classes. *Playing sport outside school* was significantly associated with a diminished risk of being obese in both sexes. The odds ratio showed a "dose response relationship" with boys and girls who frequently play sport being 62% and 81%, respectively, less likely to be obese than those who rarely play sport (reference group).

5.3.3.1.3 Participation in school PE classes

The vast majority of the adolescents (85% of boys and 91% of girls) reported that they always participate in school PE classes. There was no significant association between *participation in PE classes* and risk of obesity in both the boys (P=0.998) and girls (P=0.637).

5.3.3.1.4 Hours of TV watching

There was no significant difference in mean hours of TV viewing per day between boys (2.65±1.7) and girls (2.82±1.5) (P=0.248). Fifty eight percent of the boys and 67% of the girls reported watching TV for more than three hours per day. There was a trend towards increasing obesity with increasing hours of TV viewing which reached significance levels in boys only (P=0.020). Boys who watched TV for more than 3 hours per day were three times as likely to be obese than those watching for less than 2 hours per day (OR=2.9, 95%CI=1.1 to 7.4).

5.3.3.1.5 Hours of sedentary activities

More than twice as many girls (57%) as boys (26%) reported spending more than 4 hours per day in sedentary activities other than TV viewing. In both sexes, hours of sedentary activities showed no statistically significant trend suggestive of an association with obesity (P=0.301 in boys and P=0.146 in girls). However, rates of obesity were highest among boys (34%) and girls (41%) who spent more than 4 hours per day in sedentary activities compared to those who devoted less than 2 hours per day for such activities (26%) and (22%), respectively. When the analysis was repeated with both sexes combined, a statistically significant relationship emerged (P=0.018). The risk of being obese was 1.93 (95%CI= 1.13 to 3.31) times more for adolescents engaging in sedentary activities for more than 4 hours per day than in those who spent less than 2 hours per day in such activities.

Table 5.23. Crude association of physical activity behaviours and obesity in adolescent Bahraini males and females by obese (≥85th) and non-obese (<85th) categories of BMI for age percentile (Model-I), N=506 (249 males and 257 females)

Variable	Males						Females					
	BMI for age percentile[1]						BMI for age percentile[1]					
	≥85th Obese		<85th Non-obese		P-Value	Odds ratio (95%CI)	≥85th Obese		<85th Non-obese		P-Value	Odds ratio (95%CI)
	n	(%)	n	(%)			n	(%)	n	(%)		
Walking/cycling to school												
No[2]	66	(33.2)	133	(66.8)	0.017	1.0*	92	(40.0)	138	(60.0)	0.295	1.0*
Yes	8	(16.0)	42	(84.0)		0.38 (0.16, 0.91)	8	(29.6)	19	(70.4)		0.63 (0.24, 1.60)
Playing sport outside school												
Seldom	43	(39.1)	67	(60.9)	0.003+	1.0*	82	(44.8)	101	(55.2)	0.001+	1.0*
Sometimes	15	(25.9)	43	(74.1)		0.54 (0.27, 1.10)	15	(28.8)	37	(71.2)		0.50 (0.26, 0.97)
Frequently	16	(19.8)	65	(80.2)		0.38 (0.20, 0.75)	3	(13.6)	19	(86.4)		0.19 (0.06, 0.68)
Participation in PE class												
Sometimes/rarely	11	(29.7)	26	(70.3)	0.998	1.0*	10	(43.5)	13	(56.5)	0.637	1.0*
Always	63	(29.7)	149	(70.3)		1.0 (0.44, 2.30)	90	(38.5)	144	(61.5)		0.81 (0.32, 2.10)
TV watching (hr/day)												
<2	6	(15.4)	33	(84.6)	0.020+	1.0*	7	(29.2)	17	(70.8)	0.129+	1.0*
2-3	18	(27.7)	47	(72.3)		2.1 (0.8, 5.9)	21	(33.9)	41	(66.1)		1.2 (0.5, 3.5)
>3	50	(34.5)	95	(65.5)		2.9 (1.1, 7.4)	72	(42.1)	99	(57.9)		1.8 (0.7, 4.5)
Sedentary activities (hr/day)												
<2	18	(25.7)	52	(74.3)	0.301+	1.0*	6	(22.2)	21	(77.8)	0.146+	1.0*
2-4	34	(29.8)	80	(70.2)		1.2 (0.6, 2.4)	34	(40.5)	50	(59.5)		2.4 (0.9, 6.5)
>4	22	(33.8)	43	(66.2)		1.5 (0.7, 3.1)	60	(41.1)	86	(58.9)		2.4 (0.9, 6.4)

1 Based on BMI for sex and age reference data of Must *et al.* (1991)
2 Go to school by car or bus
*Reference category
+ Chi square for trend

5.3.3.2 Model-II

When the analysis was repeated using Model-II of BMI category to compare obese (BMI ≥95th percentile) with the normal weight group (BMI ≥5th –<85th percentile), a trend consistent with that of Model–I was seen (Table 5.24). There was a dose-response relationship between *playing sport outside school* and obesity, which was stronger than that noted in Model-I. Boys and girls who frequently played sport had a significantly lower risk of obesity than those who seldom played sport (OR= 0.23, 95%CI =0.09 to 0.59 for boys and OR=0.11, 95%CI=0.01 to 0.83, for girls). There was no significant association between *walking/cycling to school* and weight status, but obesity was less prevalent among those who walked or cycled to school than in those who reported travelling to school by other means (12% Vs. 24% in boys and 14% Vs. 28% in girls). As in Model-I, participation in school PE showed no significant relationship with obesity in the adolescents.

Though no significant association was found between hours of TV watching and risk of obesity, there was a trend suggestive of increasing obesity with increasing hours of TV viewing. Of those teenagers who watched TV for more than 3 hours per day, 26% of the boys and 28% of the girls were classified as obese, compared with only 10% and 19% among those watching TV for less than 2 hours per day, respectively (P=0.066 for boys and P=0.346 for girls). No clear trend was observed in the relationship between hours of other sedentary activities and risk of obesity in the teenagers.

In summary, *playing sport outside school* in males and females and *walking/cycling to school* in males only were associated with a decreased risk of being obese. Boys and (at a lower level of significance) girls who watched TV for more than 3 hours per day experienced a greater risk for obesity compared to those watching for less than 2 hours per day. Hours spent in sedentary activities, other than TV viewing, showed no significant relationship with obesity in both sexes.

Table 5.24. Crude association of physical activity behaviours and obesity in adolescent Bahraini males and females by obese (≥95th) and normal weight (≥5th-<85th) categories of BMI for age (Model-II), N = 389 (189 males and 200 females).

Variable	Males						Females					
	BMI for age percentile[1]				P-Value	Odds ratio (95%CI)	BMI for age percentile[1]				P-Value	Odds ratio (95%CI)
	≥95th **Obese**		≥5th -<85th **Normal wt**				≥95th **Obese**		≥5th -<85th **Normal wt**			
	n	(%)	n	(%)			n	(%)	n	(%)		
Walking/cycling to school												
No[2]	36	(24.3)	112	(75.7)	0.095	1.0*	49	(27.5)	129	(72.5)	0.161	1.0*
Yes	5	(12.2)	36	(87.8)		0.43 (0.12, 1.23)	3	(13.6)	19	(86.4)		0.42 (0.08, 1.51)
Playing sport outside school												
Seldom	26	(32.5)	54	(67.5)	0.001⁺	1.0*	46	(32.9)	94	(67.1)	0.000⁺	1.0*
Sometimes	9	(18.8)	39	(81.3)		0.48 (0.20, 1.14)	5	(12.5)	35	(87.5)		0.29 (0.11, 0.79)
Frequently	6	(9.8)	55	(90.2)		0.23 (0.09, 0.59)	1	(5.0)	19	(95.0)		0.11 (0.01, 0.83)
Participation in PE class												
Sometimes/rarely	8	(28.6)	20	(71.4)	0.338	1.0*	9	(40.9)	13	(59.1)	0.091	1.0*
Always	33	(20.5)	128	(79.5)		0.64 (0.24, 1.76)	43	(24.2)	135	(75.8)		0.46 (0.17, 1.26)
TV watching (hr/week)												
<2	3	(9.7)	28	(90.3)	0.066⁺	1.0*	4	(19.0)	17	(81.0)	0.346⁺	1.0*
2-3	10	(20.8)	38	(79.2)		2.5 (0.6, 9.8)	13	(24.1)	41	(75.9)		1.4 (0.4, 4.7)
>3	28	(25.5)	82	(74.5)		3.2 (0.9, 11.3)	35	(28.0)	90	(72.0)		1.7 (0.5, 5.3)
Sedentary activities (hr/day)												
<2	12	(21.8)	43	(78.2)	0.838⁺	1.0*	4	(17.4)	19	(82.6)	0.466⁺	1.0*
2-4	17	(20.5)	66	(79.5)		0.9 (0.4, 2.1)	18	(27.3)	48	(72.7)		1.8 (0.5, 6.0)
>4	12	(23.5)	39	(76.5)		1.1 (0.4, 2.7)	30	(27.0)	81	(73.0)		1.8 (0.6, 5.6)

1 Based on BMI for sex and age reference data of Must *et al.* (1991)
2 Go to school by car or bus
*Reference category
⁺ Chi square for trend

5.3.4 Family history of chronic diseases

Family history of chronic diseases was determined with the question "do your parents suffer from: diabetes, heart disease and hypertension". Adolescents who reported that they did not know whether their parents had these diseases (6% to 11%) were excluded from the analysis. Reports of participants were verified by checking them against reports of their mothers, which were obtained for the sub-sample of adolescents recruited in the family environment (case/control) study. Correlations between the teenagers' reports and that of their mothers for the occurrence of diabetes, heart disease and hypertension in parents were as follows: r =0.44, $P<0.001$ for diabetes; r= 0.16, $P<0.05$ for heart disease and r =0.39, $P<0.001$ for hypertension.

5.3.4.1 Model-I

Approximately 23 % of the boys and girls reported that one or both of their parents suffered from diabetes (Table 5.25). Among the males, a strong relationship between parental diabetes and obesity was observed ($P<0.001$), whereas in females the association was not strong and significant ($P=0.120$). Of those teenagers whose parents had diabetes, 51% of the boys and 49% of the girls were obese compared to 27% and 38% obese among those in whom neither parent had diabetes, respectively. The risk of being obese in boys of diabetic parents was 2.87 (95%CI =1.45 to 5.69) and in girls was 1.59 (95%CI =0.85 to 2.99).

Eight percent of the boys and 5% of the girls had parents who suffered from heart disease and about 26% and 24%, respectively, had one or two parents with a history of hypertension. Neither heart disease nor hypertension in parents was found to be associated with obesity in the adolescents of both genders. Of those boys and girls who reported heart disease in parents, 28% and 50% were classified as obese compared to 33% and 39% obese in those neither of whose parents suffered from heart disease, respectively. The prevalence of obesity in participants whose parents were hypertensive was 34% in both the boys and girls, whereas the prevalence of obesity in the non-hypertensive parent group was 33% and 41%, respectively.

Table 5.25. Crude association of family history of chronic diseases of adolescent Bahraini males and females by obese (≥85th) and non-obese (<85th) categories of BMI for age (Model I)

Variable	Males						Females					
	BMI for age percentile[1]						BMI for age percentile[1]					
	≥85th Obese		<85th Non-obese		P-Value	Odds ratio (95%CI)	≥85th Obese		<85th Non-obese		P-Value	Odds ratio (95%CI)
	n	(%)	n	(%)			n	(%)	n	(%)		
Diabetes in parents[2]												
No	46	(26.6)	127	(73.4)	0.000	1.0*	71	(37.8)	117	(62.2)	0.120	1.0*
Yes	27	(50.9)	26	(49.1)		2.87 (1.45-5.69)	29	(49.2)	30	(50.8)		1.59 (0.85-2.99)
Heart disease in parents[3]												
No	68	(32.9)	139	(67.1)	0.659	1.0*	90	(38.5)	144	(61.5)	0.424	1.0*
Yes	5	(27.8)	13	(72.2)		0.79 (0.21-2.47)	6	(50.0)	6	(50.0)		1.60 (0.41-6.17)
Hypertension in parents[4]												
No	52	(32.7)	107	(67.3)	0.866	1.0*	73	(40.8)	106	(59.2)	0.359	1.0*
Yes	19	(33.9)	37	(66.1)		1.06 (0.53-2.11)	19	(33.9)	37	(66.1)		0.75 (0.38-1.46)

1 based on BMI for sex and age reference data of Must *et al.* (1991)
2 Subjects in whom diabetes in parents was reported
3 Subjects in whom heart disease in parents was reported
4 Subjects in whom hypertension in parents was reported
*Reference category

5.3.4.2 Model-II

When the association between parental occurrence of chronic diseases and obesity in children was further examined in the obese (BMI≥95th percentile) and the normal weight group (BMI ≥5th – <85th percentile), parental diabetes continued to be significant in the male group (*P*<0.001) (OR=4.1, 95%CI = 1.8 to 9.4) (Table 5.26). As in Model–I, no significant association was detected between diabetes in parents and obesity in females. Heart disease and hypertension in parents showed no association with obesity in both the boys and girls.

In summary, boys who had one or both parents with a history of diabetes demonstrated a greater risk of being obese than those in whom neither parent was diabetic. There was no significant relationship between obesity in adolescents and parents' history of heart disease or hypertension

Table 5.26. Crude association of family history of chronic diseases and obesity in adolescent Bahraini males and females by obese (≥95th) and normal weight (≥5th-<85th) categories of BMI for age (Model-II)

Variable	Males						Females					
	BMI for age percentile[1]				P-Value	Odds ratio (95%CI)	BMI for age percentile[1]				P-Value	Odds ratio (95%CI)
	≥95th Obese		≥5th -<85th Normal wt				≥95th Obese		≥5th -<85th Normal wt			
	n	(%)	n	(%)			n	(%)	n	(%)		
Diabetes in parents[2]												
No	22	(16.8)	109	(83.2)	0.000	1.0*	34	(23.6)	110	(76.4)	0.039	1.0*
Yes	19	(45.2)	23	(54.8)		4.09 (1.79-9.40)	18	(39.1)	28	(60.9)		2.08 (0.97-4.46)
Heart disease in parents[3]												
No	37	(23.6)	120	(76.4)	1.00	1.0*	48	(26.1)	136	(73.9)	0.439	1.0*
Yes	3	(20.0)	12	(80.0)		0.81 (0.14-3.24)	3	(37.5)	5	(62.5)		1.70 (0.25-9.09)
Hypertension in parents[4]												
No	25	(21.0)	94	(79.0)	0.160	1.0*	37	(27.2)	99	(72.8)	0.823	1.0*
Yes	15	(31.3)	33	(68.8)		1.71 (0.75-3.87)	12	(25.5)	35	(74.5)		0.92 (0.40-2.07)

1 based on BMI for sex and age reference data of Must *et al*, (1991)
2 Subjects in whom diabetes in parents was reported
3 Subjects in whom heart disease in parents was reported
4 Subjects in whom hypertension in parents was reported
*Reference category

5.3.5 Multivariate analysis

To determine the independent influence of the studied variables on the outcome variable (obesity defined according to Model-I and Model-II of BMI category), multivariate models were estimated (for each sex separately). The adjusted odds ratios and their corresponding 95% CI are presented in Tables 5.27 to 5.30.

5.3.5.1 Model-I

Late night snacking, diabetes in parents, walking/cycling to school and *playing sport outside school* were all independently associated with obesity in male adolescents (Table 5.27). Boys who frequently snacked late at night were three times as likely to be obese as those who rarely did so (OR=3.01, 95%CI= 1.45 to 6.27). Compared to those with no family history of diabetes, boys with one or both diabetic parents had 2.58 times (95%CI=1.3 to 5.11) greater risk of being obese. The risk of being obese was significantly lower among boys who walked or cycled to school than in those who travelled to school by other means (OR= 0.26, 95% CI =0.10 – 0.63). Playing sport outside school was associated with a 60% reduction in risk of obesity among boys (OR=0.40, 95%CI=0.22 - 0.74).

Table 5.28 shows the adjusted odd ratios for obesity in female adolescents. *Mother's level of education, distress eating*, frequency of *eating meals with the family* and *playing sport outside school* were all independent factors associated with obesity in girls. Odds ratio relating obesity in girls to mother's education showed a significant dose response relationship. Compared with girls of poorly educated mothers, girls whose mothers had middle or high education had 2.98 (CI=1.30- 6.79) and 3.72 (CI=1.71- 8.16) greater risk of obesity, respectively. Girls who ate when upset or angry (distress eating) were more than three times at risk of being obese than those who rarely did so. Eating meals with other family members was associated with an 82% reduction in risk of obesity. Compared to those who rarely played any sport outside school, girls who frequently played sport had less risk for developing obesity (OR=0.31, CI=0.16-0.61).

Table 5.27. Multivariate analysis of selected factors based on BMI percentile category-Model-I for male adolescents (N=226)

Factor	Odds ratio (95%CI)*	P -value**
Factors associated with increased risk:		
-Snacking late at night	3.01 (1.45- 6.27)	0.003
-Diabetes in parents	2.58 (1.31-5.11)	0.006
Factors associated with reduced risk:		
-Walking/cycling to school	0.26 (0.10- 0.63)	0.003
-Play sport outside school	0.40 (0.22-0.74)	0.003

*Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for age and other variables in the table.
**Wald test

Table 5.28. Multivariate analysis of selected factors based on BMI percentile category–Model-I for female adolescents (N=257)

Factor	Odds ratio (95%CI)*	P -value**
Factors associated with increased risk:		
- Mother education		
Low	Reference category	0.004
Middle	2.98 (1.30- 6.79)	0.010
High	3.72 (1.71 –8.16)	0.001
-Distress eating[1]	3.20 (1.40-7.31)	0.006
Factors associated with reduced risk:		
- Eating with the family frequently	0.18 (0.07-0.46)	0.000
- Playing sport outside school	0.31 (0.16–0.61)	0.001

1 Eating when upset, angry or in negative mood
*Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for age and other variables in the table.
**Wald test

5.3.5.2 Model–II

When multivariate logistic regressions were carried out using Model–II, which categorises the dependent variable BMI into obese and normal weight, neither *late-night snacking* nor *walking/cycling to school* were significantly related to obesity in boys (Table 5.29). However, *eating snacks in the afternoon* showed a significant association with the outcome variable, i.e. obesity. Boys who frequently took afternoon snacks were more than twice as likely to become obese as those who demonstrated the opposite behaviour. The adjusted odds ratio for d*iabetes in parents* and *playing sport outside school* showed a stronger association with obesity than that observed in Model-I, (OR =3.66, 95%CI=1.63 to 8.18 and OR=0.29, 95%CI=0.14 to 0.64 respectively), indicating that both variables were independent contributing factors to the risk of obesity among Bahraini adolescent boys.

In the females, *mother's education, distress eating, eating with the family and playing sport outside school* continued to be independently associated with the risk of being obese (Table 5.30). Girls whose mothers had a high level of education and those who reported frequent distress eating were six and seven times, respectively, more likely to be obese compared to the reference group. Girls who ate meals with their family and those who played sport outside school had a more than 80% reduction in the risk of obesity.

Table 5.29. Multivariate analysis of selected factors based on BMI percentile category-Model-II for male adolescents (N=173)

Factor	Odds ratio (95%CI)*	P –value**
Factors associated with increased risk:		
- Eating afternoon snack	2.32 (1.02 –5.28)	0.046
- Diabetes in parents	3.66 (1.63- 8.18)	0.002
Factor associated with reduced risk:		
- Playing sport outside school	0.29 (0.14 –0.64)	0.002

*Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for age and other variables in the table.
**Wald test

Table 5.30. Multivariate analysis of selected factors based on BMI percentile category–Model-II for female adolescents (N=200)

Factor	Odds ratio (95%CI)*	P –value**
Factors associated with increased risk:		
-Mother's education		
Low	Reference category	0.003
Middle	2.62 (0.82-8.40)	0.106
High	6.00 (2.04-17.67)	0.001
-Distress eating[1]	7.05 (2.44-20.41)	0.000
Factors associated with reduced risk:		
- Eating with the family	0.12 (0.04-0.39)	0.000
- Playing sport outside school	0.16 (0.06-0.44)	0.000

1Eating when upset, angry or in negative mood
*Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for age and other variables in the table.
**Wald test

In summary, frequent snacking and family history of diabetes in boys and level of mother's education and distress eating in girls were all independent factors associated with an increased risk of obesity. Factors associated with a reduced risk of obesity included playing sport outside school in both boys and girls, walking or cycling to school in boys and eating with family in girls only.

5.4 THE FAMILY ENVIRONMENT AS A DETERMINANT OF OBESITY

The relationship between obesity in the adolescents and perinatal factors, parental obesity and other factors related to the family environment was investigated in a separate case control study involving 214 (107 obese and 107 non-obese) adolescents and their parents. The two sexes were combined in all the analyses because of the small sample size.

Examination of the findings of the case control study showed a resemblance with findings of the cross-sectional study, suggesting similarities between the two populations.

5.4.1 Socio-demographic factors

Table 5.31 shows crude association of socio-demographic factors (parents' age, occupation and level of education and number of child's siblings) and obesity in the adolescents.

5.4.1.1 Parents' age

Mean age (years) of obese and non-obese adolescents' fathers was 48.0 ± 8.9 and 47.0 ± 9.2, and that of obese and non-obese adolescents' mothers was 41.5 ±6.2 and 41.5 ± 7.6, respectively. There were no significant differences in the mean age of obese and non-obese adolescents' parents (P>0.05). Chi square statistics showed no significant association between father's age and mother's age (categorised into two groups: less than 40 years and 40 years or more) and risk of obesity in children.

5.4.1.2 Parents' occupation

A significant association was found between father's occupation and obesity in the adolescents (P=0.007). Obese adolescents were more than twice as likely to be the children of fathers with non-manual jobs (professionals, civil servants, in private businesses) than controls. No significant odds ratio for mother's occupation was found, but the percentage of obese children whose mothers were working was higher (21%) than that among the non-obese group (15%).

5.4.1.3 Parents' education

Obese teenagers had significantly greater odds of being the children of highly educated mothers than the non-obese group (OR=2.15, 95% CI=1.09 - 4.25). There was no significant difference between obese and non-obese children in relation to the level of education attained by the fathers. However, 47% of the obese adolescents' fathers had a high education level compared to 42% among the non-obese.

5.4.1.4 Number of siblings

There was no significant difference (P=0.121) in the number of siblings between obese and non obese adolescents, but 43% of the obese group had less than four siblings compared to 33% among the non-obese group.

In summary, father's occupation and mother's education were the only socio-demographic variables that were significantly related to the risk of obesity in the adolescents. Obese adolescents were more likely to be the children of highly educated mothers and fathers who worked in non-manual jobs, than the non-obese.

5.4.2 Perinatal factors

An attempt was made to investigate the associations between perinatal factors, including body weight at birth and breastfeeding, and risk of development of obesity during adolescence. To guard against inaccurate reporting of birthweight, the mother's report was verified against the maternity hospital discharge card, which is usually kept with the birth certificate and given to the mother upon leaving the hospital. For those children with missing discharge cards, name of the maternity hospital, date of birth and mother's personal number of the Civil Population Registry (CPR) were used to obtain the child's birthweight from the hospital records. Of the total number (214), only 5 (2%) had missing birth weight data (child was born abroad or in a private hospital).

Table 5.31. Crude association of socio-demographic factors and obesity in the adolescents

Age & Socio-demographic characteristics	Weight status[1]						
	Obese		Non-obese		Total	P-value	Odds ratio (95%CI)
	n	(%)	n	(%)			
Father's age (yr)							
<40	14	(13.7)	18	(17.5)	32	0.459	1.0*
>40	88	(86.3)	85	(82.5)	173		1.33 (0.59-3.04)
Mother's age (yr)							
<40	55	(52.4)	51	(48.1)	106	0.535	1.0*
>40	50	(47.6)	55	(51.9)	105		0.84 (0.47-1.50)
Father's occupation[2]							
Manual	31	(30.4)	50	(48.5)	81	0.007	1.0*
Non-manual	71	(69.6)	53	(51.5)	124		2.16 (1.17-3.99)
Mother's occupation							
Not Working	83	(79.0)	90	(84.9)	173	0.268	1.0*
Working	22	(21.0)	16	(15.1)	38		1.49 (0.69-3.22)
Father's education[3]							
Low	22	(21.6)	24	(23.3)	46	0.522+	1.0*
Middle	32	(31.4)	36	(35.0)	68		0.97 (0.46, 2.05)
High	48	(47.1)	43	(41.7)	91		1.22 (0.60, 2.48)
Mother's education[3]							
Low	22	(21.0)	35	(33.0)	57	0.027+	1.0*
Middle	33	(31.4)	34	(32.1)	67		1.54 (0.75, 3.16)
High	50	(47.6)	37	(34.9)	87		2.15 (1.09, 4.25)
Number of siblings							
0-3	46	(43.0)	35	(32.7)	81	0.121	1.0*
4+	61	(57.0)	72	(67.3)	133		0.64 (0.36, 1.17)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
2. Father's occupation: manual= skilled and unskilled workers and unemployed, non manual= professional, civil servants and in private businesses
3. Level of education: low= illiterate and read and write only, middle= primary and intermediate school, high= high school and college

*Reference category
+ Chi square for trend

5.4.2.1 Birthweight

The relationship between birthweight and subsequent obesity in children is not clear and contradictory results have been reported. Both low birthweight and high birthweight have been found to be associated with later obesity.

Mean body weight at birth (Kg) of obese and non-obese adolescents was, 3.18 ±0.55 and 3.10 ± 0.49, respectively. Student's t-test showed no significant difference in mean birthweight between the obese and non-obese groups (*P*=0.271). However, there was a tendency for obese adolescents to have a higher body weight at birth than the non-obese. Sixty percent of the obese children had a birthweight above 3.0 kg compared to 51% in the non-obese group (Table 5.32), but the odds ratio showed no significant change in the likelihood for high birthweight among the obese group (OR=1.49, 95%CI=0.83- 2.69).

5.4.2.2 Breastfeeding

Information on breastfeeding was obtained with the question, "what was the type of milk given to the child during the first six months of life: breast milk, formula, both breast milk and formula". Exclusive breastfeeding was defined in two categories: "yes" if breast milk was the only type of liquid feeding given to the infant during the first six months of life and "no" if the infant was given formula only or was partially breastfed (i.e. breast milk supplemented with formula). Maternal reports of breastfeeding and breastfeeding duration are frequently used in epidemiological studies. Mother's recall of their children's infant feeding habits have been shown to have an acceptable level of validity and reliability (Tomeo *et al.*, 1999).

Fifty seven percent of the adolescent participants were exclusively breastfed, 33% were partially breastfed (breast milk and formula) and 10% were fed formula during the first six months of life. Of the obese children, 51% were exclusively breastfed compared to 63% in the non-obese group (*P*=0.083) (Table 5.32). The odds ratio, however, did not show a significant decrease in the likelihood of being breastfed among obese children compared to the non-obese group (OR=0.62, 95% CI=0.34 - 1.11).

In summary, neither birthweight nor breastfeeding appears to be a significant factor associated with risk of obesity among Bahraini teenagers.

Table 5.32. Crude association of perinatal factors and obesity in the adolescents

Variable	Weight status[1]				Total	p-value	Odds ratio (95%CI)
	Obese		Non-obese				
	n	(%)	n	(%)			
Birthweight (g)							
≤3000	42	(39.6)	51	(49.5)	93	0.150	1.0*
>3000	64	(60.4)	52	(50.5)	116		1.49 (0.83, 2.69)
Exclusive breastfeeding							
No[2]	51	(48.6)	39	(36.8)	90	0.083	1.0*
Yes	54	(51.4)	67	(63.2)	121		0.62 (0.34 - 1.11)

1.Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
2. Formula only + partial breastfeeding (i.e. breast milk supplemented with formula)
*Reference category

5.4.3 Obesity in parents and other relatives

5.4.3.1 Parental obesity

Obesity in parents, defined as BMI value equal to, or greater, than 30 kg/m^2 (WHO, 2000), was examined to assess its relationship with obesity in the children. Since many parents did not know their height and weight, these measurements were performed on all mothers and fathers during the home interview or at a later home visit. The only exception was 8 fathers who were unavailable (busy or out of the country) at the time of data collection. This group of fathers was asked to have their weight and height taken in their local health center or pharmacy and the information was then collected by phone. From weight and height measurements BMI was calculated and used to determine mothers' and fathers' obesity status. Because 3 of the mothers and 9 of the fathers were dead, the number of mothers and fathers with complete weight and height data was 211 and 205, respectively.

Forty three percent of the mothers and 25% of the fathers were obese (Table 5.33). There was a strong and direct relationship between adolescents' obesity and parental obesity. Compared to the non-obese, obese children were 3 and 2.4 times more likely to have obese mothers and obese fathers, respectively. When the analysis was repeated with obesity in mothers and fathers combined, the estimated odds ratio for parental obesity showed a significant increasing trend (P<0.001). Obese adolescents were 3.8 times (95%CI=2.03-7.04) more likely to have one obese parent and 6.5 times (95%CI=2.31- 8.31) more likely to have both parents obese than controls.

5.4.3.2 Obesity among other relatives (siblings, grandparents, aunts/uncles)

The presence of obesity among other relatives was ascertained by asking mothers whether the child had an obese sibling, grandparent, aunt or uncle. Significant associations were observed between obesity in adolescents and mother's reported (perceived) occurrence of obesity among the adolescent's relatives (Table 5.34). Eighty one percent of the obese teenagers had an obese relative compared to only 52% among the non-obese group ($P<0.001$). Obese adolescents had a significantly greater odds ratio for having one or more obese relative than the controls (OR=3.96, CI= 2.05 to 7.71). The highest likelihood of obesity in relatives was observed among siblings, followed by grandparents and then uncles/aunts. Compared to the non-obese, obese teenagers were 3.7, 2.2 and 2 times as likely to have an obese sibling, grandparent and uncle/aunt, respectively. When the analysis was repeated using the total number of different types of obese relatives as the independent variable, a significant dose response relationship emerged, indicating that familial factors are important determinants of obesity among adolescents in Bahrain. However, since in many Bahraini families, grandparents, uncles and aunts live together in the same house with the child's parents and siblings, it is possible that environmental factors are also responsible for the observed aggregation of obesity among these families.

In summary, obesity in children is strongly and positively associated with the presence of obesity among parents and other relatives.

Table 5.33. Crude association of parental obesity and obesity in adolescents

Variable	Weight status[1]				Total	P-value	Odds ratio (95%CI)
	Obese		Non-obese				
	n	(%)	n	(%)			
Mother obese[2]							
No	46	(38.0)	75	(62.0)	121	0.000	1.0*
Yes	59	(65.6)	31	(34.4)	90		3.10 (1.69-5.72)
Father obese[2]							
No	68	(44.4)	85	(55.6)	153	0.009	1.0*
Yes	34	(65.4)	18	(34.6)	52		2.36 (1.17-4.79)
Parents obese[2]							
Neither parent obese	27	(27.0)	62	(60.8)	89	0.000+	1.0*
One parent obese	56	(56.0)	34	(33.3)	90		3.78 (2.03, 7.04)
Both parents obese	17	(17.0)	6	(5.9)	23		6.51 (2.31, 8.31)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
2. Obese= BMI ≥30, non-obese =BMI <30 (WHO, 2000)
*Reference category
+ Chi square for trend

Table 5.34. Crude association of obesity in relatives and obesity in adolescents

Variable	Weight status[1]				Total	p-value	Odds ratio (95%CI)
	Obese		Non-obese				
	n	(%)	n	(%)			
Child has an obese relative							
No	20	(18.7)	51	(47.7)	71	0.000	1.0*
Yes	87	(81.3)	56	(52.3)	143		3.96 (2.05-7.71)
Obese sibling							
No	65	(60.7)	91	(85.0)	156	0.000	1.0*
Yes	42	(39.3)	16	(15.0)	58		3.67 (1.82-7.50)
Obese grandparent							
No	74	(69.2)	89	(83.2)	163	0.016	1.0*
Yes	33	(30.8)	18	(16.8)	51		2.20 (1.10-4.46)
Obese aunt/uncle							
No	45	(42.1)	63	(58.9)	108	0.013	1.0*
Yes	62	(57.9)	44	(41.1)	106		1.97 (1.11-3.53)
Number of obese relatives							
0	28	(26.2)	53	(49.5)	81	0.000+	1.0*
1	33	(30.8)	33	(30.8)	66		1.89 (0.97, 3.68)
2	34	(31.8)	18	(16.8)	52		3.58 (1.72, 7.44)
3	12	(11.2)	3	(2.8)	15		7.57 (1.97, 29.07)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
*Reference category
+ Chi square for trend

5.4.3.3 BMI heritability among Bahraini adolescents

Genetic factors play an important role in the aetiology of obesity. One of the statistical methods developed to determine the heritability level of traits is the Risch's lambda coefficient (λ_R) (Risch, 1990). λ_R can be defined as [P (A\ R)] / [P (A)], where P (A) is the probability of being affected with the trait (i.e. the population prevalence of obesity) and P (A\R) is the probability of being affected given that one's relative of the degree R is affected. In this study an attempt was made to estimate the Risch's lambda coefficient (λ_R) for the heritability of obesity among Bahraini adolescents. λ_R was calculated for the mother and child pairs and for the father and child pairs using the tables of Allison *et al.* (1996) which provide estimates of λ_R as a function of the Pearson correlation coefficient of BMI between relatives of degree R and the population prevalence of obesity. The overall prevalence of obesity (≥95th percentile) in the male and female adolescent participants was 18.4%. The Pearson correlation coefficient calculated for the child-mother pairs (n=211) and the child-father pairs (n=205) were 0.38 ($P<0.01$) and 0.205 ($P<0.01$), respectively. The BMI heritability index (λ_R) derived from the tables of Allison *et al.* (1996) for Bahraini adolescents was found to be 1.88 for the mother-offspring pairs and 1.42 for the father-offspring pairs.

5.4.4 Parents' history of chronic diseases

Table 5.35 shows the crude association between the reported presence of diabetes, heart disease and hypertension among the mothers and fathers, and obesity in their children. Obesity in adolescents was significantly related to diabetes in parents. Of the obese adolescents, 21% had a diabetic mother and 25.5% had a diabetic father as compared to 5% and 11% among the non-obese group, respectively. Obese adolescents were 5.4 (95%CI=1.86- 18.76) and 2.9 (95%CI=1.25- 6.63) times more likely than controls to have diabetic mothers and diabetic fathers, respectively. In contrast, no significant differences in the prevalence of parental heart disease or hypertension were observed between the obese and non-obese children and odds ratios for adolescent obesity did not show any significant increase in the likelihood of having parents with a history of heart disease or hypertension. These results were consistent with the findings of the cross sectional study.

In summary, diabetes in parents was the only variable among parental chronic diseases that showed a significant association with obesity in Bahraini teenagers.

Table 5.35. Crude association of parents' history of chronic diseases and obesity in adolescents

Parent's history of chronic diseases (reported)	Weight status[1]				Total	p-value	Odds ratio (95%CI)
	Obese		Non-obese				
	n	(%)	n	(%)			
Diabetes in mother							
No	83	(79.0)	101	(95.3)	184	0.000	1.0*
Yes	22	(21.0)	5	(4.7)	27		5.35 (1.86, 18.76)
Diabetes in Father							
No	76	(74.5)	92	(89.3)	168	0.006	1.0*
Yes	26	(25.5)	11	(10.7)	37		2.86 (1.25, 6.63)
Heart disease in mother							
No	97	(92.4)	103	(97.2)	200	0.118	1.0*
Yes	8	(7.6)	3	(2.8)	11		2.83 (0.65-16.97)
Heart disease in father							
No	98	(96.1)	98	(95.1)	196	0.744	1.0*
Yes	4	(3.9)	5	(4.9)	9		0.80 (0.15, 3.84)
Hypertension in mother							
No	88	(83.8)	95	(89.6)	183	0.213	1.0*
Yes	17	(16.2)	11	(10.4)	28		1.67 (0.69, 4.06)
Hypertension in father							
No	88	(86.3)	89	(86.4)	177	0.978	1.0*
Yes	14	(13.7)	14	(13.6)	28		1.01 (0.43, 2.41)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
*Reference category

5.4.5 Mother's dietary habits and behavioural factors

Mother's dietary habits and behavioural factors were explored along the same lines used in the cross sectional study, but no significant associations with the occurrence of obesity status among adolescent children were found except for *eating breakfast daily* and *frequency eating of take-away foods*. Table 5.36 summarises the results of the bivariate analysis.

5.4.5.1 Eating breakfast daily

A significant association between eating breakfast by mothers and risk of adolescent's obesity was observed. Obese adolescents were 2.6 times more likely to be the children of mothers who skipped breakfast than controls (OR=2.61, 95%CI=1.38- 4.94).

5.4.5.2 Intake of take-away foods

Sixty percent of mothers reported consuming take-away foods twice a week or more. Compared to controls, obese adolescents were nearly twice as likely to be the children of mothers who ate take-away foods two times or more per week (OR=1.87, 95% CI=1.04 - 3.39).

In summary, *eating breakfast daily* and *intake of take-away foods* were the only variables among mother's dietary habits and behavioural factors that appeared to be associated with obesity in children. Obese adolescents were more likely to be the children of mothers who skipped breakfast and consumed take-away foods twice or more per week than the non-obese.

5.4.6 Mother's lifestyle characteristics

Lifestyle characteristics of mothers, namely physical exercise, hours of TV watching and presence of domestic helper were examined to assess the relationship between these factors and risk of obesity in the adolescent children (Table 5.37).

5.4.6.1 Physical exercise

A significant association was observed between mother's physical activity behaviour and obesity status of the children. Sixty six percent of the obese teenagers' mothers did not do regular exercise, versus 51% among the non-obese group (P=0.026). Compared to controls, obese boys and girls were nearly two times more likely to be the children of mothers who did not indulge in regular exercise (OR=1.86, 95%CI=1.04- 3.37).

Table 5.36. Crude association of mother's dietary and behavioural factors and obesity in adolescents

Variable	Weight status[1]				Total	p-value	Odds ratio (95%CI)
	Obese		Non-obese				
	n	(%)	n	(%)			
Eating breakfast daily							
Yes	61	(57.0)	83	(77.6)	144	0.001	1.0*
No[2]	46	(43.0)	24	(22.4)	70		2.61 (1.38-4.94)
Distress eating[3]							
Rarely	78	(72.9)	75	(70.1)	153	0.649	1.0*
Frequently	29	(27.1)	32	(29.9)	61		0.87 (0.46-1.65)
Late night snacking							
Rarely	73	(68.2)	78	(72.9)	151	0.453	1.0*
Frequently	34	(31.8)	29	(27.1)	63		1.25 (0.67-2.36)
Eating meals with the child							
Frequently	95	(88.8)	99	(92.5)	194	0.347	1.0*
Rarely	12	(11.2)	8	(7.5)	20		1.56 (0.56-4.41)
Eating meals while watching TV							
No	40	(37.4)	48	(44.9)	88	0.266	1.0*
Yes	67	(62.6)	59	(55.1)	126		1.36 (0.76-2.44)
Intake of take-away foods (times per week)							
<2	35	(32.7)	51	(47.7)	86	0.025	1.0*
>2	72	(67.3)	56	(52.3)	128		1.87 (1.04-3.39)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
2. Sometimes or rarely
3. Eating when upset, angry or in negative mood
*Reference category

5.4.6.2 Hours of TV viewing

When obese and non-obese children were compared in relation to mother's hours of TV viewing (categorised in tertiles) a significant increasing trend of odds ratios was observed (P=0.002). Compared to the non-obese, obese adolescents were about three times more likely to be the sons and daughters of mothers who watched TV for more than 16 hours per week.

5.4.6.3 Domestic help

Forty one percent of the obese children's mothers reported having at least one domestic helper compared to 21% in the non-obese group (P=0.001). Obese adolescents had significantly higher odds of having domestic help at home than the non-obese (OR=2.70, 95% CI=1.41 to 5.19).

In summary, mothers' lifestyle is strongly associated with the occurrence of obesity among children. Obese teenagers are more likely to be the sons and daughters of mothers who did not engage in physical exercise, spent more than 16 hours per week watching TV and had a domestic helper than the non-obese.

Table 5.37. Crude association of mother's lifestyle characteristics and obesity in adolescents

Variable	Weight status[1]				Total	p-value	Odds ratio (95%CI)
	Obese		Non-obese				
	n	(%)	n	(%)			
Exercise							
Yes	36	(33.6)	52	(48.6)	88	0.026	1.0*
No	71	(66.4)	55	(51.4)	126		1.86 (1.04-3.37)
TV viewing tertiles (hr/week)							
1 (0-7)	23	(21.5)	41	(38.3)	64	0.002+	1.0*
2 (9 –16)	40	(37.4)	39	(36.4)	79		1.83 (0.93, 3.59)
3 (>16)	44	(41.1)	27	(25.2)	71		2.90 (1.44, 5.85)
Domestic helper							
No	63	(58.9)	85	(79.4)	148	0.001	1.0*
Yes	44	(41.1)	22	(20.6)	66		2.70 (1.41-5.19)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
*Reference category
+ Chi square for trend

5.4.7 Parental influence over child's eating and physical activity behaviour

In order to investigate whether differences in parenting style are associated with the occurrence of obesity in the children, questions designed to elicit information about parenting style in relation to child's eating habits and physical activity were included in the interviewer-administered questionnaire (see Appendix 4B). Factors studied included mother's degree of control over child's eating, maternal influence over child's consumption of particular foods (by encouraging/discouraging), mother's use of food as reward and her use of verbal prompts to increase child's eating and physical activity. Results of the bivariate analysis and crude odds ratio are presented in Table 5.38.

5.4.7.1 Mother's degree of control over child's eating

Parental degree of control over child's eating at meal-times was assessed by asking the mother about how she would react if the child were not hungry at mealtime. A significant difference was observed between obese and non-obese children in relation to the mother's response to such an event. Compared to the non-obese, obese boys and girls were less likely to be the children of mothers who would convince them to sit at the table and eat when they expressed no hunger at meal-times (OR=0.52, 95%CI=0.27 - 0.97). Mother's degree of control over the child's intake of sweets and high calorie snacks was assessed with the following two questions: " To what degree can your child eat sweets without your knowledge/permission: frequently, rarely" and "Usually when the child eats sweets and snacks: he buys or helps himself to them, he asks for them or they are offered by parents".

Forty three percent of the obese children's mothers reported that their children rarely consumed snacks and sweets without their knowledge/permission compared to 57% of the controls. However, the difference between the two groups was only marginally significant (P=0.055). In relation to the method of obtaining (accessing) sweets and snacks, a significant difference was observed between the two groups. Compared to the non-obese, obese children had significantly lower odds for being the children of mothers who demonstrated controlling behaviour (i.e. less likely to get sweets and snacks by asking mother for them or when they were being offered by her) (OR=0.30, CI=0.16 to 0.55).

5.4.7.2 Mother's influence over child's consumption of food

More than 70% of mothers reported having encouraged or discouraged their children from eating certain foods. Foods encouraged included fruits and vegetables (53%), milk (19%) and fish (15%). Foods discouraged included sweets (34%), Pepsi (20%) and crisps and puffed corn (18%). A significant association was observed between obesity in children and the mother's behaviour. Obese children were more likely to have mothers who would discourage (OR=2.45, 95%CI=1.24 - 4.86) but less likely to have mothers who would encourage (OR=0.51, 95%CI=0.26 - 0.99) them to eat certain foods than non-obese children.

5.4.7.3 Use of food as means of reward

Of the total number of adolescents' mothers, 31% admitted having given their children food as a means of reward. Adolescents categorised as obese had significantly lower odds for being the children of mothers who used food as a reward than controls (OR= 0.49, 95%CI=0.26 - 0.93).

5.4.7.4 Use of prompts to increase child's eating or physical activity

Seventy seven percent of mothers reported having used verbal prompts to increase their sons and daughters' eating. However, use of prompts to influence the child's food intake showed no significant relation to the occurrence of obesity among the adolescents (P=0.332). In contrast, mothers' prompting of their children to exercise was strongly associated with obesity in the teenagers. Relative to the non-obese, obese children were more than four times as likely to have mothers who frequently encouraged them to exercise than the non-obese group (OR=4.13, 95%CI=2.24-7.66).

In conclusion, compared to the non-obese, obese Bahraini teenagers were less likely to be the children of mothers who practiced a high degree of control over the child's eating behaviour, encouraged eating of certain foods or used food as reward, and more likely to be the sons and daughters of mothers who discouraged the child from eating particular foods or used verbal prompts to increase the child's physical activity.

Table 5.38. Crude association of parental influence over child's eating and physical activity behaviours and obesity in adolescents

Parenting style variables	Weight status[1] Obese n	(%)	Non-obese n	(%)	Total	p-value	Odds ratio (95%CI)
Control of eating							
How would you respond if it's a mealtime and your child is not hungry?							
Leave child alone	81	(75.7)	66	(61.7)	147	0.027	1.0*
Convince child to eat less or same	26	(24.3)	41	(38.3)	67		0.52 (0.27-0.97)
To what degree can your child eat sweets & snacks without your permission?							
Frequently	63	(56.3)	49	(43.8)	112	0.055	1.0*
Rarely	44	(43.1)	58	(56.9)	102		0.59 (0.33, 1.05)
Usually when child eats sweets & snacks:							
He buys it or helps himself to it	73	(68.2)	42	(39.3)	115	0.000	1.0*
He asks for it /offered by parents	34	(31.8)	65	(60.7)	99		0.30 (0.16, 0.55)
Influence over consumption of particular types of foods							
Have you ever encouraged your child to eat a particular type of food?							
No	36	(33.6)	22	(20.6)	58	0.031	1.0*
Yes	71	(66.4)	85	(79.4)	156		0.51 (0.26-0.99)
Have you ever discouraged your child from eating a particular type of food?							
No	19	(17.8)	37	(34.6)	56	0.005	1.0*
Yes	88	(82.2)	70	(65.4)	158		2.45 (1.24-4.86)
Use of food as means of reward							
Have you ever given your child food as a kind of reward?							
Rarely	82	(76.6)	66	(61.7)	148	0.017	1.0*
Frequently	25	(23.4)	41	(38.3)	66		0.49 (0.26-0.93)
Use of prompts to increase child's eating/physical activity							
Have you ever used verbal prompts to increase child's eating?							
Rarely	28	(26.2)	22	(20.6)	50	0.332	1.0*
Frequently	79	(73.8)	85	(79.4)	164		0.73 (0.37-1.45)
Have you ever used verbal prompts to increase child's physical activity?							
Rarely	30	(28.0)	66	(61.7)	96	0.000	1.0*
Frequently	77	(72.0)	41	(38.3)	118		4.13 (2.24, 7.66)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
*Reference category

5.4.8 Availability and accessibility of food in the home

Home environment in relation to availability and accessibility of sweets and snacks was investigated by using a 12-item list of common types of sweets and high calorie snacks (see questionnaire in Appendix 4B). Mothers were asked to chose those items that were usually available in the house and to say whether they were kept in a reachable place or unseen place. There was no significant difference in the mean number of sweets and snacks found in the homes of obese (5.75 ±2.7) and non-obese (5.78 ±2.5) (*P*=0.937). When chi square statistics were used to compare obese and non-obese children in terms of the number of sweets and snacks usually available in their homes (categorized into two categories: 0 to 5 items and 6 items or more), 52% of the obese children's mothers reported the availability of more than 6 items of these foods compared to 56% among the non-obese group (Table5.39). However, the difference was not statistically significant (*P*=0.583). Similarly, there was no significant association between obesity in the adolescents and the ease of access of sweets and snacks in the homes of these children. In about 39% of the obese adolescents' homes these items were kept in a reachable place, compared to 36% in the controls group (*P*=0.672).

The relationship between obesity in the adolescents and the frequency of availability of fresh fruits in the household was explored with the question " In your house how often are fresh fruits available: always, most of the time, sometimes, rarely". The majority of mothers (86%) reported that fresh fruits were always/most of the time available in the house. Nine percent of the obese children's mothers reported having fresh fruits sometimes/rarely as compared to 18% of the non-obese group. However, the odds ratio for the availability of fruits within the household did not show any significant association with the occurrence of obesity among the adolescents (OR= 0.48, 95%CI=0.19-1.15).

In summary, no significant difference was observed between the obese and non-obese children in terms of the availability and accessibility of sweets, high calorie snacks or fruits.

Table 5.39. Crude association of home environment in relation to the availability and accessibility of food and obesity in adolescents

Variable	Weight status[1]				Total	p-value	Odds ratio (95%CI)
	Obese		Non-obese				
	n	(%)	n	(%)			
Number of types of sweets/snacks usually found in the house							
<6	51	(47.7)	47	(43.9)	98	0.583	1.0*
>6	56	(52.3)	60	(56.1)	116		0.86 (0.48, 1.53)
Snacks/sweets kept in a reachable place							
No	65	(60.7)	68	(63.6)	133	0.672	1.0*
Yes	42	(39.2)	39	(36.4)	81		1.13 (0.62-2.03)
Fruits are available							
Always/most of the time	97	(90.7)	88	(82.2)	185	0.072	1.0*
Sometimes/rarely	10	(9.3)	19	(17.8)	29		0.48 (0.19-1.15)

1. Obese ≥85th percentile of BMI for age and ≥90th percentile of TSKF and SSKF for age, non-obese <85th percentile of BMI for age and < 90th percentile of TSKF and SSKF for age (WHO, 1995)
*Reference category

5.4.9 Multivariate analysis

Multivariate models were estimated with obesity in adolescents as the dependent variable; independent variables included all the family environment variables that showed a statistical significance below the 0.2 level in the crude analysis. The adjusted odds ratios and their corresponding 95% confidence intervals are presented in Tables 5.40 to 5.43.

5.4.9.1 Multivariate analysis conducted on selected factors

Adjusting for mother's education and father's occupation, mother's dietary behaviours and lifestyle variables namely, eating breakfast and physical exercise, and parent's BMI and history of diabetes were all found to be independently related to obesity in the Bahraini teenagers (Table 5.40). Obese adolescents were 2.4 times more likely to be the children of mothers who skipped breakfast and 3.4 times more likely to have mothers who did not indulge in exercise, than controls. Adjusted odds ratios showed that obese adolescents had a 3 and 5 times greater likelihood of having one obese parent and both parents obese, respectively. Odds for having obese relatives (other than parents) were also significantly higher for the obese group. Compared to the non-obese, children classified as obese were nearly 5 times more likely to have a diabetic mother and 4 times more likely to have a diabetic father.

Table 5.40. Multivariate analysis of selected factors related to the family environment

Factor	Odds ratio (95%CI)$	P -value+
Eating breakfast		
Yes	1.0*	0.023
No	2.39 (1.13-5.10)	
Exercise		
Yes	1.0*	0.001
No	3.42 (1.64- 7.12)	
Parents obesity status[1]		
Neither parents obese	1.0*	0.005
One parent obese	2.60 (1.26-5.34)	0.010
Both parents obese	5.17 (1.58- 16.94)	0.007
Child have an obese relative(s)		
No	1.0*	0.002
Yes	3.32 (1.54-7.14)	
Diabetes in mother		
No	1.0*	0.008
Yes	4.79 (1.51-15.16)	
Diabetes in father		
No	1.0*	0.007
Yes	3.64 (1.41-9.39)	

1. Obese parent =BMI ≥30, non-obese parent= BMI <30 (WHO, 2000)
$ Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for father's occupation, mother's education as well as other variables in the table.
+ Wald's test
*Reference category

5.4.9.2 Multivariate analysis conducted on obesity among parents and other relatives

The odds ratios for obesity in parents and other relatives, adjusted for mother's education and father's occupation, showed strong and independent associations with obesity in the teenager (Table 5.41). Compared to the non-obese, obese children had a 3-fold greater likelihood of having one obese parent and an over 5-fold higher likelihood of having both parents who were obese. Similarly, the number of different types of obese relatives (other than parents) remained highly associated with obesity in the adolescents. Compared to the non-obese, obese boys and girls had 2, 3 and 5 times greater odds to have one, two and three different types of obese relations, respectively.

Table 5.41. Multivariate analysis of obesity among parents and other relatives

Factor	Odds ratio (95%CI)$	P -value+
Parents obesity status[1]		
Neither parents obese	1.0*	0.001
One parent obese	3.01 (1.55, 5.82)	0.001
Both parents obese	5.46 (1.82, 16.41)	0.002
Number of obese relatives[2]		
0	1.0*	0.020
1	1.75 (0.84, 3.62)	0.134
2	3.18 (1.38, 7.33)	0.006
3	4.64 (1.13, 19.12)	0.034

1. Parent obese = BMI ≥30, non-obese =BMI <30
2. Obesity (reported) among siblings, grandparents, aunts and uncles
$ Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for father's occupation, mother's education and other variables in the table.
+ Wald's test
*Reference category

5.4.9.3 Multivariate analysis conducted on mother's lifestyle variables

Table 5.42 shows the odds ratios (adjusted for mother's education and obesity status) for lifestyle characteristics of adolescents' mothers. Lack of exercise, having a domestic helper and increased hours of TV viewing were all significantly and independently associated with increased risk of obesity in children. Obese teenagers were more than two times as likely as the non-obese to be the children of mothers who did not engage in regular exercise (OR=2.07, 95%CI=1.12-3.83), had a domestic helper (OR=2.25, 95%CI=1.10-4.61) and watched TV for more than 16 hours per week (OR=2.74, 95%CI=1.27- 5.91).

Table 5.42. Multivariate analysis of mother's lifestyle variables

Factor	Odds ratio (95%CI)$	P -value+
Exercise		
Yes	1.0*	0.020
No	2.07 (1.12, 3.83)	
Domestic helper		
No	1.0*	0.026
Yes	2.25 (1.10, 4.61)	
TV viewing tertiles (hr/week)		
1 (0-7)	1.0*	0.033
2 (9 -16)	1.46 (0.71, 3.05)	0.315
3 (>16)	2.74 (1.27, 5.91)	0.010

$ Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for mother's education and obesity status as well as other variables in the table.
+ Wald's test
*Reference category

5.4.9.4 Multivariate analysis conducted on factors related to parental influence over child's eating and physical activity behaviours

When multivariate analysis was conducted and after controlling for mother's education and mother's obesity status and other confounding variables, factors related to parenting style remained strongly and independently associated with obesity in the adolescents, except for *encourage child to eat particular types of food* which was weakly associated with obesity (*P*=0.069) (Table 5.43). Obese children were less likely than controls to be the children of mothers who demonstrated controlling behaviour over the child's access to sweets and snacks (OR= 0.32, 95%CI=0.17- 0.62) or mothers who used food as a means of reward (OR=0.45, 95%CI=0.22 -0.93). Compared to controls, obese adolescents were more than twice as likely to be the sons and daughters of mothers who discouraged consumption of certain foods and about 4 times as likely to be the offspring of mothers who encouraged physical activity.

Table 5.43. Multivariate analysis of factors related to parental influence over child's eating and physical activity behaviours

Factors	Odds ratio (95%CI)$	P -value+
Factors associated with reduced risk:		
Usually when child eats sweets & snacks:		
He buys it or helps himself to it	1.0*	0.001
He asks for it /offered by parents	0.32 (0.17, 0.62)	
Have you ever given your child food as a kind of reward?		
Rarely	1.0*	0.030
Frequently	0.45 (0.22, 0.93)	
Have you ever encouraged your child to eat a particular type of food?		
No	1.0*	0.069
Yes	0.50 (0.24, 1.06)	
Factors associated with increased risk:		
Have you ever discouraged your child from eating a particular type of food?		
No	1.0*	0.025
Yes	2.39 (1.12, 5.13)	
Have you ever used verbal prompts to increase child's physical activity?		
Rarely	1.0*	0.000
Frequently	3.94 (2.02, 7.71)	

$ Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for mother's education and obesity status as well as other variables in the table.
+ Wald's test
*Reference category

5.5 BLOOD PRESSURE AND OBESITY AMONG ADOLESCENTS

Obesity is an established risk factor for high blood pressure in children and adolescents (Freedman *et al.*, 1999a; Williams *et al.*, 1992). The relationship between blood pressure and obesity was investigated in the adolescent participants of this study. Only two girls (<1%) refused BP measurement. As a result, the number of subjects included in the analysis was 504. The means and standard deviations of SBP in the male and female participants were 122.9±16.5 mmHg and 118.6±14.1 mmHg and those of DBP were 72.1±12.1 mmHg and 70.1±11.7 mmHg, respectively. Mean SBP was significantly higher in boys than in girls (*P*=0.002), but no statistically significant difference in mean DBP between the two sexes was observed (*P*=0.057). The correlation between blood pressure and age in the adolescents, investigated by the Spearman rank correlation, was found to be significant for SBP and was stronger in males (r =0.44, *P*<0.001) than in females (r =0.21, *P*=0.001), but not for DBP (r = -0.02, *P*=0.818 in boys and r =0.07, *P*=0.295 in girls).

5.5.1 Relationship between blood pressure and anthropometric indicators

The age-adjusted correlation coefficients between blood pressure and the anthropometric indicators are presented in Table 5.44. Height, weight, BMI, triceps and subscapular skinfolds, percent body fat and fat mass were all significantly related to SBP and to DBP in both sexes. In girls the correlation between SBP and fat indices (percent body fat and fat mass) was stronger than in boys. Fat free mass was significantly correlated with SBP and DBP in boys but not in girls. The strongest correlation observed for SBP was with weight. Of the fat patterning indices, waist circumference showed the strongest correlation with SBP and DBP.

An attempt was made to assess the independent influence of these variables on SBP by multiple regression analysis. Since DBP was highly correlated with SBP (r =0.59, *P*<0.001), multivariate analysis was carried out on SBP only.

Table 5.44. Age-adjusted correlation coefficient (r) of SBP and DBP and selected anthropometric indicators in the adolescents, n =249 males, n = 255 females

Anthropometric indicator	Sex			
	Males		Females	
	SBP	DBP	SBP	DBP
Height	0.399***	0.413***	0.286***	0.302***
Weight	0.434***	0.303***	0.519***	0.411***
BMI	0.358***	0.210**	0.504***	0.376***
Triceps skinfold	0.285***	0.184**	0.433***	0.370***
Subscapular skinfold	0.302***	0.188**	0.483***	0.373***
% Body fat	0.279***	0.176**.	0.468***	0.381***
Fat mass	0.304***	0.196**	0.490***	0.392***
Fat free mass	0.422***	0.332***	0.093 N.S.	0.061 N.S.
Waist hip ratio	0.210**	0.144*.	0.305***	0.142*
Subscapular triceps ratio	0.081 N.S.	0.029 N.S.	0.201**	0.105 N.S.
Waist circumference	0.379***	0.266***	0.513***	0.374***

***$P<0.001$
**$P<0.01$
*$P<0.05$
N.S. Non-significant

Linear regression of systolic blood pressure was conducted on the following independent variables: age, percent fat, STR and weight and height. Because of the difficulty in separating the effects of these variables, as they were highly correlated with each other, the selected independent variables were entered in three steps. Age was entered into the first step, followed by percent body fat and STR and both height and weight were entered in the last step. The regression models for both sexes are presented in Table 5.45. Age was significantly associated with SBP, especially in boys, accounting for 18 % of the SBP variations. Percent fat but not STR was significantly associated with SBP in both boys and girls ($P<0.001$). The increment in R^2 value, when these two variables were entered, ranged from 7% in boys to 25.5% in girls. Weight and height in boys and weight only in girls were significantly associated with SBP, independent of age, percent fat or STR. The value of R^2 in the final model was 0.37 and 0.29 in boys and girls, respectively. When weight and height were tested along with percent fat and STR, by entering them together in step 2, and after adjusting for age, only weight in females and weight and height in males remained in the final model. These findings indicate that body size is more important than either body fat or fat patterning in explaining differences in systolic blood pressure among the adolescents.

Table 5.45. Multivariate analysis of SBP on age and selected anthropometric variables in adolescents.

	Standardized coefficient of anthropometric variables+					
	Age	Percent fat	STR	Weight	Height	Adjusted R^2
Males						
Step: 1	0.43***	-	-	-	-	0.18
2	0.39 ** *	0.27 ***	0.11	-	-	0.25
3	0.04	- 0.15	0.02	0.49 **	0.23*	0.37
Females						
Step: 1	0.23 ***	-	-	-	-	0.05
2	0.12 *	0.44***	0.09	-	-	0.26
3	0.07	0.08	0.06	0.41 **	0.06	0.29

+ Estimated by stepwise linear regression
* $P<0.05$, ** $P<0.01$, *** $P<0.001$

The means and standard deviations of SBP and DBP of the adolescent participants by their obesity status are presented in Table 5.46. Mean SBP was significantly higher ($P<0.001$) among adolescents with BMI ≥85th percentile than in those with BMI <85th percentile of the BMI reference (Must *et al.*, 1991). A statistically significant difference between the obese and non-obese group was also found for DBP in both boys ($P=0.005$) and girls ($P<0.001$).

Table 5.46. Mean and standard deviation (SD) of SBP and DBP by obesity status in adolescent Bahraini males and females

	N	Mean (SD)	t	P -value
Males				
SBP				
Obese[1]	74	129.9 (15.8)	4.47	0.000
Non-obese[2]	175	120.0 (15.9)		
DBP				
Obese[1]	74	75.4 (10.1)	2.86	0.005
Non-obese[2]	175	70.7 (12.6)		
Females				
SBP				
Obese[1]	99	125.4 (13.9)	6.56	0.000
Non-obese[2]	156	114.4 (12.5)		
DBP				
Obese[1]	99	74.9 (11.4)	5.57	0.000
Non-obese[2]	156	66.9 (10.8)		

1 BMI ≥85th percentile of BMI for age and sex reference values of Must *et al.* (1991)
2 BMI <85th percentile of BMI for age and sex reference values of Must *et al.* (1991)

5.5.2 Association of obesity, body fat distribution and blood pressure

In this study, efforts were taken to investigate the association between BMI, percent body fat, body fat distribution and physical activity behaviour, and the risk of having an elevated blood pressure among the adolescent participants. The definition of high blood pressure was based on the report of the Second Task Force on Blood Pressure Control in Children (Task Force on Blood Pressure Control in Children, 1987), which was recommended by the WHO expert committee on hypertension control (WHO, 1994).

The dependent variable blood pressure status was categorised as follows:

1- High BP (SBP and/or DBP ≥95th percentile for sex and age)

2- Normal BP (SBP and/or DBP <95th percentile for sex and age)

Of the total sample with complete BP readings (n=504), seventy participants (14%) were found to have SBP and/or DBP at or above the 95th percentile of the reference values, which put them in the high blood pressure category. Of these, 45 were males (18% of total male sample) and 25 were females (10% of total female sample). The associations between the selected variables and the risk of high blood pressure summarised using cross-tabulations and crude odds ratios are presented in Tables 5.47 and 5.48. Factors studied included, age, BMI percentile category, percentage body fat, WC, WHR and behaviours related to physical activity. WHR and WC were categorised using internal cut-off points (tertiles). Percent body fat categories were based on the classification system proposed by Ellis (1996).

There was no significant association between socio-economic variables, such as parents' occupation and level of education, and blood pressure status among adolescents (data not shown). In boys, but not in girls, age was found to be significantly related to increased risk of having high blood pressure (P=0.005). Compared to 12-13 year olds, boys in mid (14-15 years) to late adolescence (16-17 years) were about 3 times more likely to have increased blood pressure. Using BMI as an indicator of obesity, a dose-response relationship was found between obesity status and risk of having elevated blood pressure. Boys and girls with BMI ≥95th percentile were nearly 4 and 11 times as likely as those with BMI below the 85th percentile to be classified as having high blood pressure, respectively. Similarly, the risk of having elevated blood pressure increased with increasing levels of percent body fat. Boys and girls who had 35% or more body fat were 4 and 6 times more likely to be classified in the high blood pressure category compared to the reference group, respectively.

Waist circumference, a measure of central obesity, showed a significant association with the risk of having high blood pressure in both sexes (Table 5.48). Boys and girls in the uppermost tertile of WC were approximately 7 times as likely as those in the lowest tertile of this measurement to have elevated blood pressure. In contrast WHR showed a statistically significant relationship with risk of high blood pressure status in the female subjects only (P=0.006, OR= 4.3, 95% CI=1.4, 13.3). Adjusting for age did not affect the odds ratios of anthropometric variables (BMI percentile category, percent body fat and waist circumference) and risk of having elevated blood pressure (Table 5.49).

Table 5.47. Factors associated with blood pressure in adolescent Bahraini males and females by high and normal blood pressure status, n=504 (249 males and 255 females)

Variable	Males						Females					
	BP status[1] High n	High %	BP status[1] Normal n	Normal %	P-value	Odds ratio (CI)	BP status[1] High n	High %	BP status[1] Normal n	Normal %	P-value	Odds ratio (CI)
Age (yr)												
12-13	9	(10.3)	78	(89.7)	0.005+	1.0*	7	(7.7)	84	(92.3)	0.956+	1.0*
14-15	15	(17.6)	70	(82.4)		2.6 (1.3-5.4)	12	(14.8)	69	(85.2)		0.9 (0.3-2.7)
16-17	21	(27.3)	56	(72.7)		3.3 (1.4-7.6)	6	(7.2)	77	(92.8)		0.9 (0.3-2.9)
BMI percentile[2]												
<85th	21	(12.0)	154	(88.0)	0.000+	1.0*	6	(3.8)	150	(96.2)	0.000+	1.0*
85th-95th	10	(30.3)	23	(69.7)		2.9 (1.6-5.1)	3	(6.4)	44	(93.6)		8.0 (3.3-19.4)
≥95th	14	(34.1)	27	(65.9)		3.8 (1.7-8.4)	16	(30.8)	36	(69.2)		11.1 (4.1-30.4)
Percent body fat[3]												
<25	22	(13.0)	147	(87.0)	0.000+	1.0*	2	(3.2)	60	(96.8)	0.001+	1.0*
25-35	8	(21.1)	30	(78.9)		2.7 (1.6-4.8)	4	(5.1)	75	(94.9)		5.2 (1.2-21.5)
>35	15	(35.7)	27	(64.3)		3.7 (1.7-8.1)	19	(16.7)	95	(83.3)		6.0 (1.4-26.7)

1 Based on the report of the Second Task Force on Blood Pressure Control in Children, 1987
2. BMI for age category: BMI < 85th percentile= underweight and normal weight, BMI 85th -95th percentile= overweight, BMI ≥95th percentile = obese
3 Calculated using equations of Slaughter *et al*, 1988. Percent body fat classification is based on Ellis K. J, 1996
* Reference category
+ Chi-square for trend

Table 5.48. Factors associated with blood pressure in adolescent Bahraini males and females by high and normal blood pressure status, n=504 (249 males and 255 females)

Variable	Males						Females					
	BP status[1]				P-value	Odds ratio (CI)	BP status[1]				P-value	Odds ratio (CI)
	High		Normal				High		Normal			
	n	%	n	%			n	%	n	%		
WC tertiles												
1	5	(6.0)	79	(94.0)	0.000+	1.0*	3	(3.7)	79	(96.3)	0.000+	1.0*
2	15	(17.4)	71	(82.6)		3.34 (1.15-9.65)	3	(3.7)	79	(96.3)		1.0 (0.2-5.11)
3	25	(31.6)	54	(68.4)		7.31 (2.64-20.30)	19	(20.9)	72	(79.1)		6.95 (1.97-24.47)
WHR tertiles												
1	6	(14.6)	35	(85.4)	0.171+	1.0*	6	(4.8)	120	(95.2)	0.006+	1.0*
2	12	(14.1)	73	(85.9)		1.5 (0.7-3.4)	11	(13.1)	73	(86.9)		3.7 (1.4 – 10.2)
3	27	(22.0)	96	(78.0)		1.6 (0.6-4.3)	8	(17.8)	37	(82.2)		4.3 (1.4-13.3)
Walking/cycling to school												
No	41	(20.6)	158	(79.4)	0.038	1.0*	24	(10.5)	204	(89.5)	0.489	1.0*
Yes	4	(8.0)	46	(92.0)		0.34 (0.08, 1.0)	1	(3.7)	26	(96.3)		0.33 (0.01, 2.19)
Playing sport outside school[2]												
Seldom	25	(22.7)	85	(77.3)	0.089	1.0*	22	(12.1)	160	(87.9)	0.052	1.0*
Frequently	20	(14.4)	119	(85.6)		0.57 (0.28, 1.15)	3	(4.1)	70	(95.9)		0.31 (0.06, 1.09)

1 Based on the report of the Second Task Force on Blood Pressure Control in Children, 1987
2 Category "Seldom " was obtained by collapsing "sometimes" and "seldom" and category "frequently" was obtained by collapsing "always" and "frequently"
* Reference category
+Chi-square for trend
Key: *WC = Waist circumference, WHR Waist to hip circumference ratio*

Table 5.49. Age-adjusted odds ratios of selected anthropometric variables for dependent variable blood pressure status (high/normal), n=504

Factor	Male		Females	
	P- value+	OR (95% CI)	P- value+	OR (95% CI)$
BMI percentile				
<85th	0.001	1.0*	0.000	1.0*
85th-95th	0.009	3.30 (1.4-8.1)	0.466	1.71 (0.4-7.1)
≥95th	0.001	3.85 (1.7-8.6)	0.000	11.26 (4.1-30.9)
Percent body fat				
<25	0.004	1.0*	0.007	1.0*
25-35	0.223	1.76 (0.7-4.4)	0.562	1.67 (0.3-9.5)
>35	0.001	3.82 (1.7-8.4)	0.016	6.45 (1.4-29.3)
WHR tertiles				
1	0.215	1.0*	0.027	1.0*
2	0.860	1.10 (0.4-3.2)	0.035	3.11 (1.1-8.7)
3	0.190	1.9 (0.7-5.2)	0.010	4.38 (1.4-13.5)
Waist circum. tertiles				
1	0.002	1.0*	0.000	1.0*
2	0.077	2.72 (0.9-8.2)	0.957	1.05 (0.2, 5.4)
3	0.001	6.10 (2.1-17.5)	0.002	7.33 (2.1-26.3)

$Odds ratio and 95% confidence interval calculated using logistic regression, adjusted for age.
* Reference category
+ Wald's test

Physical activity behaviour variables included *walking/cycling to school* and *playing sport outside school.* A significant association between blood pressure status and method of travelling to school was observed among boys (P=0.038), but the odds ratio did not show a significant reduction in risk of high blood pressure (OR=0.34, 95%CI=0.08 - 1.0). In girls, there was no statistically significant difference between those who walked or cycled to school and those who travelled to school by other means (P=0.489). *Playing sport outside school* showed no significant association with risk of having high blood pressure in both boys (P=0.089) and girls (P=0.052). However, high blood pressure was less prevalent among those boys and girls who reported playing sport frequently than among those who rarely played sport (14% Vs. 23% in boys and 4% Vs. 12% in girls).

5.5.2.1 Multivariate analysis

Controlling for sex and age, the logistic regression analysis showed that *playing sport outside school* and *walking/cycling to school* were independent factors associated with reduced risk for the development of high blood pressure among adolescents (Table 5.50). However, when BMI was entered into the model, these significant associations were lost. BMI was the only variable in the model that was strongly related to BP, indicating that the observed associations between the physical activity behaviours and BP status were confounded by BMI.

Table 5.50. Multivariate analysis of selected factors for dependent variable blood pressure status (high/normal), n=504

Factor	Odds ratio (95%CI)*	P- value+
Walking/cycling to school	0.35 (0.13, 0.91)	0.031
Playing sport outside school	0.49 (0.28, 0.86)	0.014

* Odds ratio and 95% confidence interval adjusted for sex, age and other variables in the logistic regression model
\+ Wald's test

In conclusion, mean systolic blood pressure and mean diastolic blood pressure were higher in males than in females. Weight and height in boys and weight only in girls were significantly associated with systolic blood pressure independent of age, percent fat or subscapular triceps ratio. Nearly 14% of the adolescents were classified as having high blood pressure. BMI, percent body fat and waist circumference were significantly and positively associated with a risk of having high blood pressure. *Playing sport outside school* and *walking/cycling to school* were important factors associated with reduced risk of high blood pressure among Bahraini adolescents. However, this effect appears to be mediated by BMI.

5.6 PERCEPTIONS OF/AND ATTITUDES TO BODY WEIGHT AMONG ADOLESCENTS

5.6.1 Adolescents' perceptions of body weight

Perceptual body image was explored in the cross-sectional study; questions such as "do you think you are thin, about right, fat, too fat" and "what do your parents peers think of your body weight" were included in the questionnaire (Appendix 4A). The adolescents' perceptions of weight were presented in 4 categories: thin, about right, fat and too fat. These categories were converted to the equivalent categories of the BMI for age percentile classification: underweight, normal weight, overweight and obese (Must *et al.*, 1991). Adolescents who reported no self-knowledge of body image, parents' or peers' opinion on weight were excluded from the analysis. Thus the number of subjects included in the analysis is less than the total number of participants (506).

5.6.1.1 Adolescents' perceptions of current weight compared to actual weight status

Table 5.51 summarizes the adolescents' perceptions of their weight in relation to actual weight status. Ten percent of the female subjects reported themselves to be underweight compared with only 3.5% classified as underweight based on the BMI percentile-weight status. This proportion included girls of normal weight and one overweight girl. In males, perception of underweight (12%) and actual weight status (10%) was more consistent. Most of the adolescents who perceived themselves to be of normal weight were classified as normal weight (78% of boys and 84% of girls), but about 15% of the boys and girls were overweight or obese.

Of those teenagers who considered themselves to be overweight, less than one third were actually overweight (27% of boys and 32% of girls). The majority, however, were obese, based on their BMI determined weight category (53% of boys and 47% of girls). Approximately 20% of the adolescents in this group overestimated their weight.

All of the boys (100%) and most of the girls (73%) were able to correctly match a perception of obesity and actual obesity status. Twenty percent of the girls who reported being obese were in fact overweight and 7% were of normal weight.

In summary, more than three quarters (80.5% of boys and 76% of girls) of the obese and more than one third (60% of boys and 36% of girls) of the overweight adolescents perceived their body weights to be less than their actual weight status. Overall approximately 60% of the boys and girls correctly identified their weight category, 30% underestimated and 10% overestimated their current weight.

Table 5.51. Adolescents' perceptions of current weight in relation to their actual weight status

Actual weight status *	Adolescents' perceptions of current weight status				
	Underweight (%)	Normal Wt (%)	Overweight (%)	Obese (%)	Total (%)
Males					
Underweight	12 (44.4)	10 (7.0)	1 (2.2)	0	23 (10.4)
Normal weight	14 (51.9)	110 (77.5)	8 (17.8)	0	132 (59.7)
Overweight	0	18 (12.7)	12 (26.7)	0	30 (13.6)
Obese	1 (3.7)	4 (2.8)	24 (53.3)	7 (100)	36 (16.3)
Total (%)	27 (12.2)	142 (64.3)	45 (20.4)	7 (3.2)	221 (100.0)
Females					
Underweight	5 (21.7)	3 (2.6)	0	0	8 (3.5)
Normal weight	17 (73.9)	98 (83.8)	15 (21.1)	1 (6.7)	131 (58.0)
Overweight	1 (4.3)	14 (12.0)	23 (32.4)	3 (20.0)	41 (18.1)
Obese	0	2 (1.7)	33 (46.5)	11 (73.3)	46 (20.4)
Total (%)	23 (10.2)	117 (51.8)	71 (31.4)	15 (6.6)	226 (100.0)

* Based on the BMI for age percentile classification: Underweight <5th, normal weight ≥5th to <85th, overweight ≥85th to < 95th, obesity ≥95th percentile (Must *et al*, 1991).

5.6.1.2 Adolescents' perceptions of parents' opinion of current weight compared to actual weight status

Adolescents' perceptions of parents' opinion on weight in relation to their actual weight status are presented in Table 5.52. Of the total number, nearly 22% of the male and 26% of the female adolescents reported that their parents considered them to be underweight whereas, based on their BMI-weight category, only 11% and 3%, respectively, were underweight. Of those adolescents who believed that their parents' regarded them to be of normal weight, the majority (71% of boys and 78% of girls) were classified as such, less than one quarter were overweight or obese (22% of males and 19% of females) and only 7% of boys and 2% of girls were underweight. Of those boys and girls who reported a perceived parental opinion of being overweight, only 26% and 35%, respectively, were actually overweight. The majority, however, were obese (56% of the boys and 40% of the girls) but some were of normal weight (18% of the boys and 25% of the girls). All of the boys (100%) and most of the girls (85%) who reported a parental perception of being obese were in fact obese.

In summary, about half of the male and female adolescents correctly matched parental perceptions of weight with actual weight, but approximately 40% thought that their parents would consider them to be leaner than they actually were.

5.6.1.3 Adolescents' perceptions of peers' opinion of current weight compared to actual weight status

Fifty seven percent of the boys and 49% of the girls reported perception of their peers' opinion on weight that was consistent with their BMI-determined weight status (Table 5.53). While only 13% of the boys were underweight, 22% thought that their friends would consider them to be underweight. In the girls, a greater degree of discrepancy between peers' perception of underweight (24%) and actual underweight (3%) was observed. Of those adolescents who believed that their peers regarded them as normal weight, 17% of the boys and 21% of girls were overweight and 8% were obese. However, the majority of adolescents in this group (about 70%) had a BMI less than the 85th percentile (i.e. normal weight).

Of those teenagers who believed that their peers' would classify them as overweight, only 25% of the boys and 29% of the girls were actually overweight; a considerable percentage (57% of males and 46% of females) was in fact obese. Most of the boys

(67%) and the girls (89%) who reported a perception of peers' opinion of being obese were classified as obese.

In short, 36% of males and 45% of females thought that their peers considered them to be leaner than they actually were.

Table 5.52. Adolescents' perceptions of parents' opinion of weight in relation to actual weight status

Actual weight status *	Adolescents' perceptions of parents' opinion on weight				
	Underweight (%)	Normal Wt (%)	Overweight (%)	Obese (%)	Total (%)
Males					
Underweight	14 (32.6)	7 (6.5)	0	0	21 (10.7)
Normal weight	29 (67.4)	77 (71.3)	7 (17.9)	0	113 (57.7)
Overweight	0	18 (16.7)	10 (25.6)	0	28 (14.3)
Obese	0	6 (5.6)	22 (56.4)	6 (100)	34 (17.3)
Total (%)	43 (21.9)	108 (55.1)	39 (19.9)	6 (3.1)	196 (100.0)
Females					
Underweight	5 (9.1)	2 (2.3)	0	0	7 (3.3)
Normal weight	50 (90.9)	69 (78.4)	13 (25.0)	1 (5.0)	133 (61.9)
Overweight	0	13 (14.8)	18 (34.6)	2 (10.0)	33 (15.3)
Obese	0	4 (4.5)	21 (40.4)	17 (85.0)	42 (19.5)
Total (%)	55 (25.6)	88 (40.9)	52 (24.2)	20 (9.3)	215 (100.0)

* Based on the BMI for age percentile classification: Underweight <5th, normal weight ≥5th to <85th, overweight ≥ 85th to < 95th, obesity ≥95th percentile (Must *et al*, 1991).

Table 5.53. Adolescents' perceptions of peers' opinion of weight in relation to actual weight status

Actual weight status *	Adolescents' perceptions of peers' opinion on weight				
	Underweight (%)	Normal Wt (%)	Overweight (%)	Obese (%)	Total (%)
Males					
Underweight	18 (42.9)	6 (5.3)	0	0	24 (12.7)
Normal weight	23 (54.8)	79 (69.9)	5 (17.9)	1 (16.7)	108 (57.1)
Overweight	0	19 (16.8)	7 (25.0)	1 (16.7)	27 (14.3)
Obese	1 (2.4)	9 (8.0)	16 (57.1)	4 (66.7)	30 (15.9)
Total (%)	42 (22.2)	113 (59.8)	28 (14.8)	6 (3.2)	189 (100.0)
Females					
Underweight	7 (13.5)	0	0	0	7 (3.3)
Normal weight	45 (86.5)	75 (71.4)	12 (25.0)	0	132 (61.7)
Overweight	0	22 (21.0)	14 (29.2)	1 (11.1)	37 (17.3)
Obese	0	8 (7.6)	22 (45.8)	8 (88.9)	38 (17.8)
Total (%)	52 (24.3)	105 (49.1)	48 (22.4)	9 (4.2)	214 (100.0)

* Based on the BMI for age percentile classification: Underweight <5th, normal weight ≥5th to <85th, overweight ≥ 85th to < 95th, obesity ≥95th percentile (Must *et al*, 1991).

To detect whether there were significant differences between adolescents' perceived weight and actual weight status, the data (Table 5.51 to 5.53) were tested using the marginal homogeneity test, a non-parametric test for two related categorical variables that uses the chi-square distribution to test changes in responses. Table 5.54 shows the means and standard deviations of the marginal homogeneity statistic and the p-value. For both the males and females there was a statistically significant difference among the perceived and actual weight categories ($P<0.001$). This indicates that adolescents' perceptions of current weight, parents' opinion on weight and peers' opinion on body weight are not consistent with their actual weight status, i.e. the way the boys and girls perceive their bodies or think that others perceive them is different from reality.

Table 5.54. Means (SD) and P-value of adolescents' actual weight status and perceived weight status using marginal homogeneity test statistics

	Sex	N	Marginal homogeneity (MH) test		
			Mean (SD)	Std MH	P- value
1- Perception of self weight					
Actual Vs. Perceived weight	M	221	201.5 (5.07)	4.63	0.000
	F	226	239.5 (5.02)	4.68	0.000
2- Perception of parents' opinion of weight					
Actual Vs. Perceived weight	M	196	211.5 (5.17)	6.47	0.000
	F	215	238.5 (5.50)	6.64	0.000
3- Perception of peers' opinion of weight					
Actual Vs. Perceived weight	M	189	195.5 (5.45)	5.96	0.000
	F	214	257.0 (5.79)	7.95	0.000

To determine if there is any difference between the two sexes in terms of discrepancy between perceived weight and actual weight, a score system was developed. The scoring system is based on coding the categories of BMI percentiles (Must *et al.*, 1991) with values from 1-4 as shown in Table 5.55. The difference between actual weight score and perceived weight score was then calculated for males and females in each category of BMI status and then tested for statistical significance using Student's t-test. Figures 5.4 to 5.6 show a graphical representation of the relationship between the mean of difference in weight scores (actual – perceived) versus actual BMI status for the adolescents' perceptions of self, parents' opinion and peers' opinion on body weight.

Table 5. 55. Scores (1-4) corresponding to BMI percentile weight category

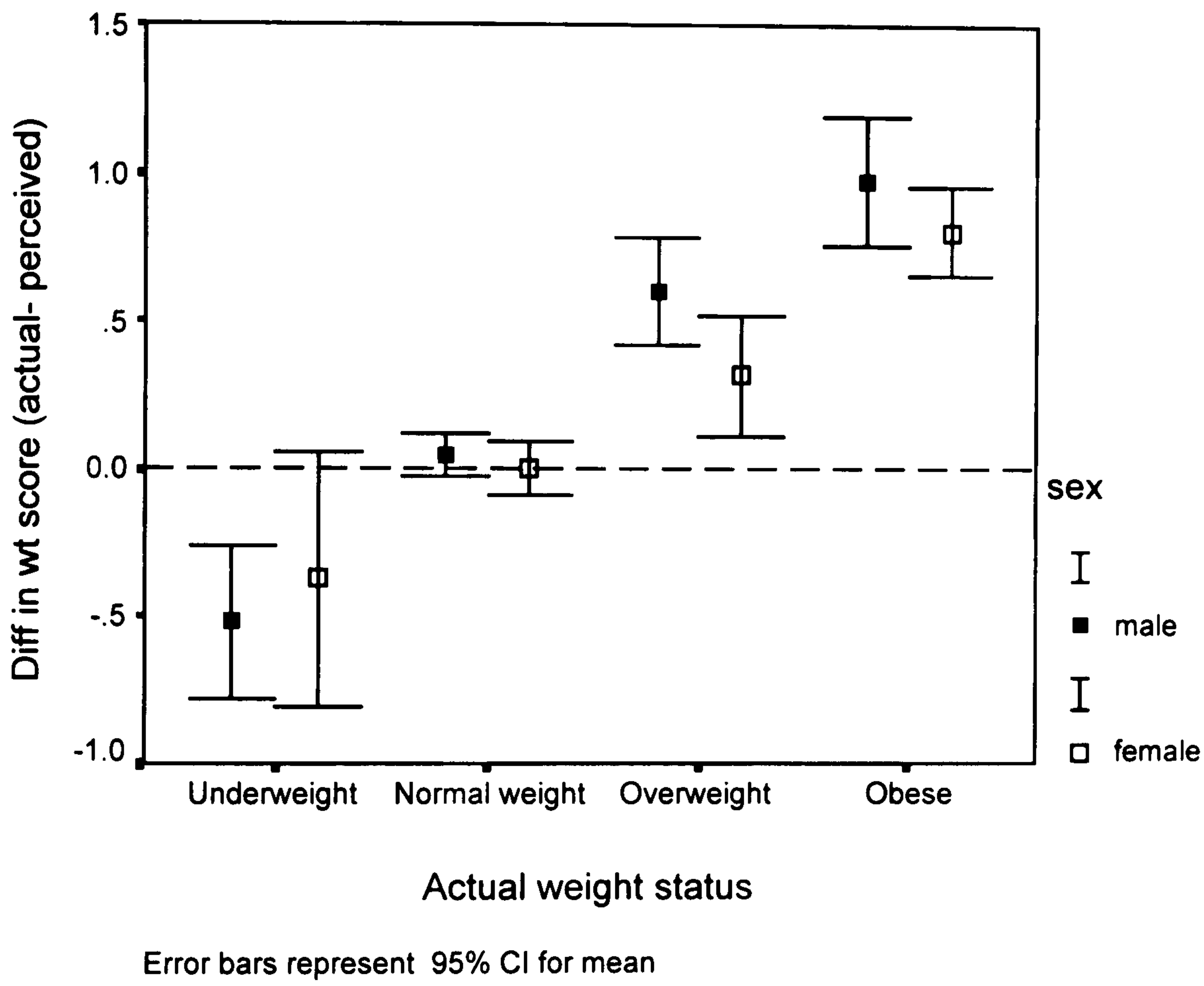
Actual /perceived weight categories*	Score
Underweight	1
Normal weight	2
Overweight	3
Obese	4

* Based on the BMI for age percentile classification: Underweight <5th, normal weight=5th to <85th, overweight =85th to 95th, obesity ≥95th percentile (Must *et al*, 1991).

Figure 5.4. shows that overweight and obese adolescents underestimated their weight; i.e. they perceived themselves to be lighter than they actually were. Interestingly, obese adolescents tended to underestimate their weight to a greater degree than did the

overweight group. Underweight males and females, however, tended to overestimate their current body weight. Normal weight adolescents were able to correctly match perceived weight and BMI weight status. In all the categories of actual weight status there was no difference between males and females in the degree of discrepancy between perceived weight and actual weight status ($P > 0.05$).

Figure 5.4. Mean of difference in weight score (actual –perceived) by adolescents' actual weight status category

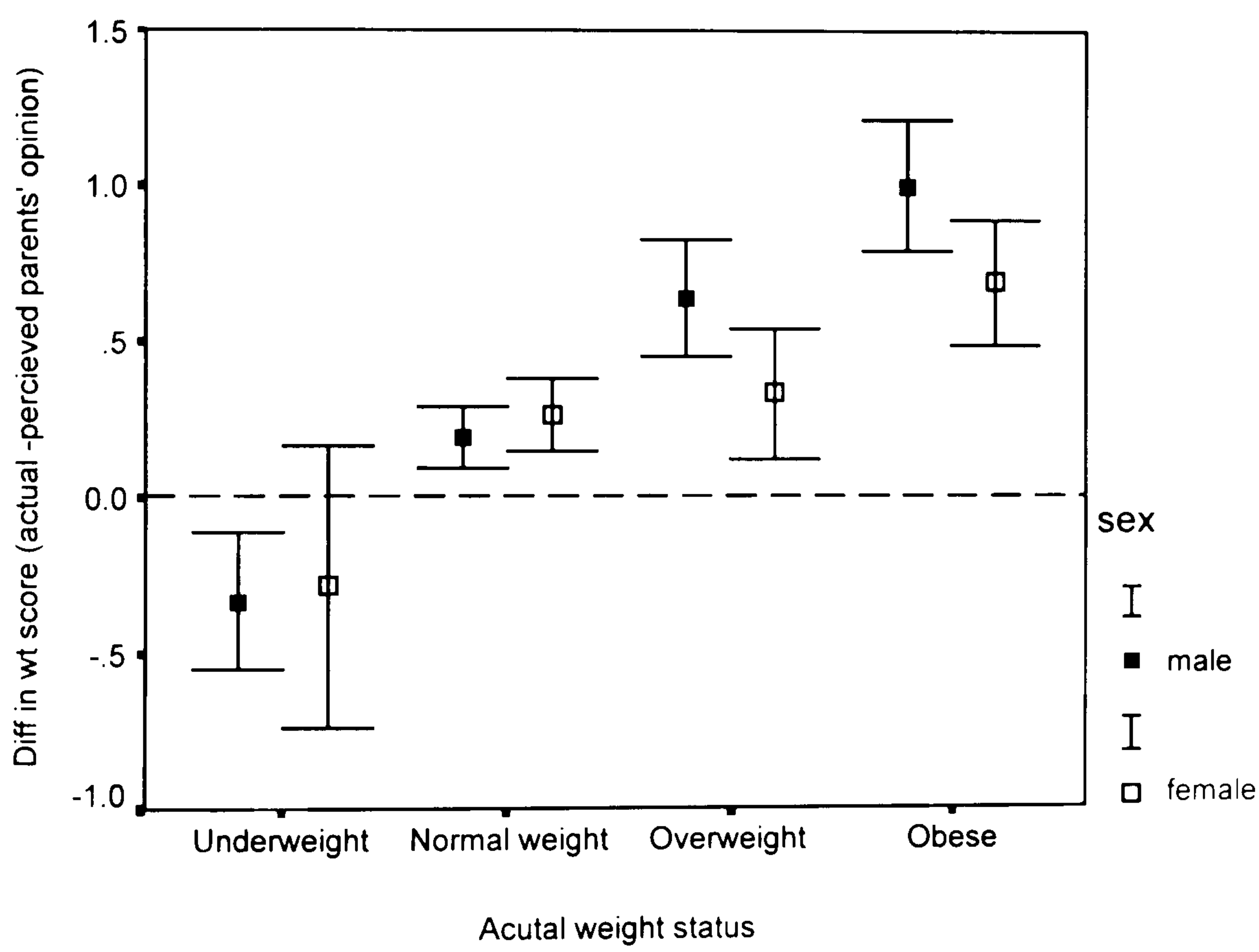


When difference in weight score was calculated for perceived parents' opinion on weight and then plotted against actual BMI weight status (Figure 5.5), all adolescents except those categorized as underweight demonstrated a positive discrepancy between actual and perceived parents' body image; i.e. overweight, obese and normal weight adolescents believe that their parents think that they weighed less than they actually did, whereas underweight adolescents believe that their parents' considered them to be heavier than their actual weight. A statistically significant difference ($P<0.05$) between the boys and girls was detected among the overweight and obese groups only.

Overweight and obese boys showed greater degree of discrepancy between actual and perceived parents' opinion on weight than girls.

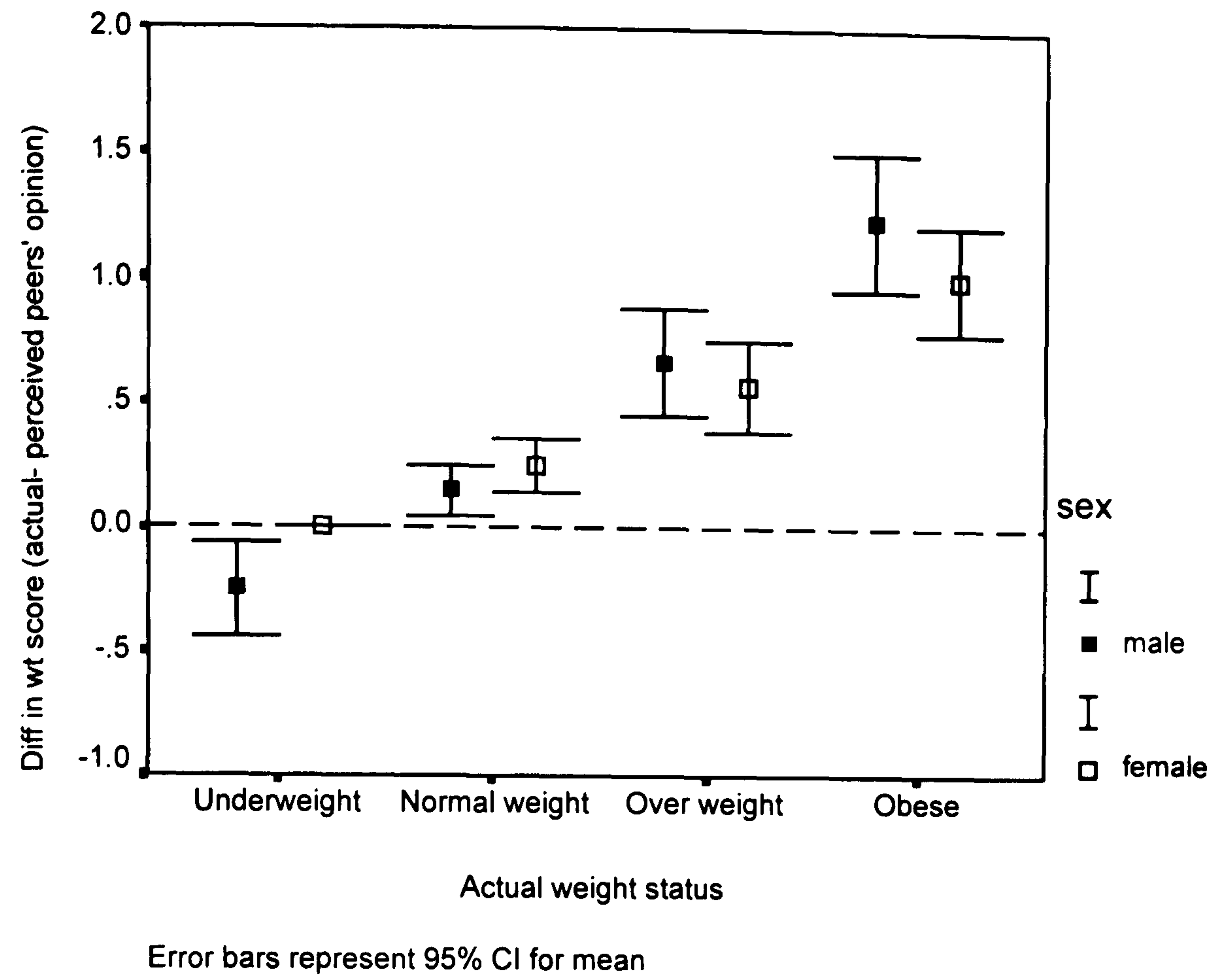
A similar pattern of misperception was observed for perceived peers' opinion of weight (Figure 5.6) with normal weight, overweight and obese participants perceiving their friends to consider them to be leaner than their actual BMI status. However, there seems to be no difference between males and females in the degree of discrepancy (*P*>0.05).

Figure 5.5. Mean of difference in weight score (actual –perceived parents' opinion) by adolescents' actual weight status category



Error bars represent 95% CI for mean

Figure 5.6. Mean of difference in weight score (actual –perceived peers' opinion) by adolescents' actual weight status category



5.6.1.4 Adolescents' perceptions of ideal body figure

To measure adolescents' perceptions of ideal body image and how they compare with their current body image we used the 9 figure silhouettes developed by Stunkard *et al.* (1983). Subjects were asked to indicate the figure (1 to 9) which most accurately represented their current body size (current body image) and which they most desired (ideal body image). Table 5.56 shows the means and standard deviations of the adolescents' perceptions of their current and ideal figures according to the actual weight category. The differences between perceived current and ideal body figure were tested for statistical significance using Student's paired t-test and presented with their P-values. It can be seen that, compared to their current body shape, underweight adolescents chose a heavier body figure as their ideal. In the normal weight group, girls perceived an ideal body figure which was significantly lighter than their current body size. In contrast boys of normal weight indicated a preference for a body figure which was significantly heavier than their current body image. Overweight and obese adolescents reported an ideal body image which was significantly lighter than their perceived current body image.

Table 5.56. Means ± standard deviations (SD) of adolescents' perceptions of current and ideal body figure

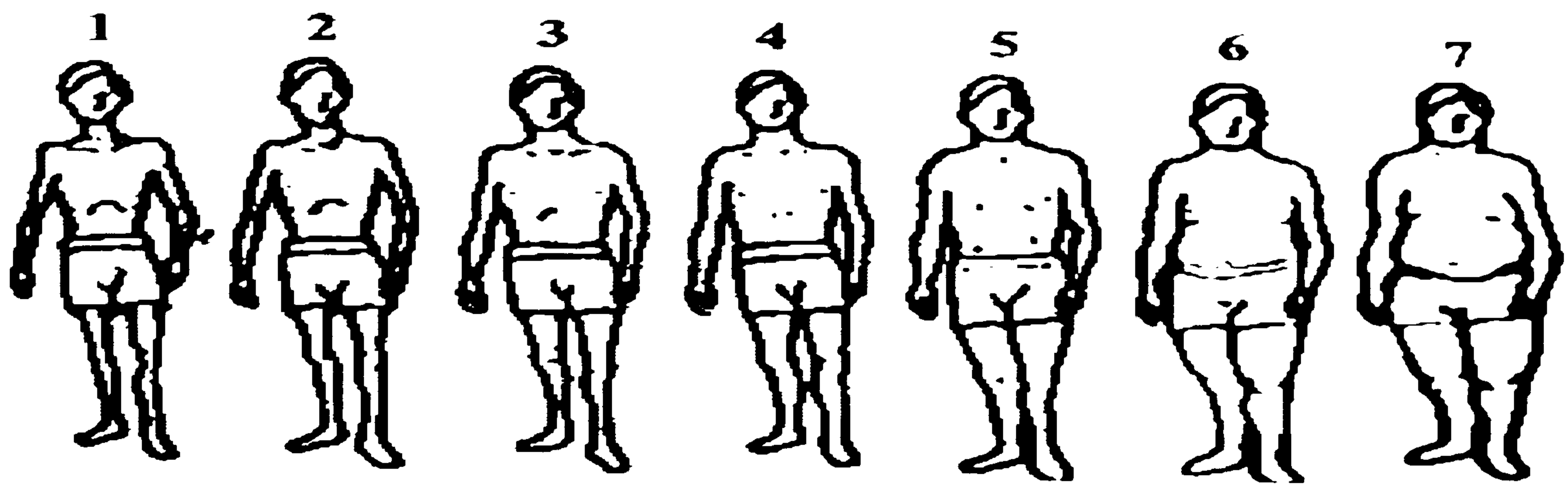
Actual weight category *	N	Body image mean ± SD		t	P-value
		Current	Ideal		
Males					
Underweight	27	3.30 ± 0.99	4.56 ± 0.85	-5.79	0.000
Normal weight	148	4.22 ± 1.02	4.51 ± 1.03	-2.73	0.007
Overweight	33	5.61 ± 0.79	4.21 ± 0.74	11.37	0.000
Obese	41	6.51 ± 1.10	4.34 ± 0.79	15.59	0.000
Females					
Underweight	9	2.44 ± 0.88	3.89 ± 0.93	-8.22	0.000
Normal weight	148	3.65 ± 1.04	3.36 ± 0.82	3.01	0.003
Overweight	48	5.15 ± 0.95	3.42 ± 0.77	10.83	0.000
Obese	52	6.27 ± 1.10	3.96 ± 0.79	21.32	0.000

* Based on the BMI for age percentile classification: Underweight <5th, Normal weight=5th to< 85th, overweight =85th to 95th, obesity ≥95th percentile (Must *et al*, 1991).

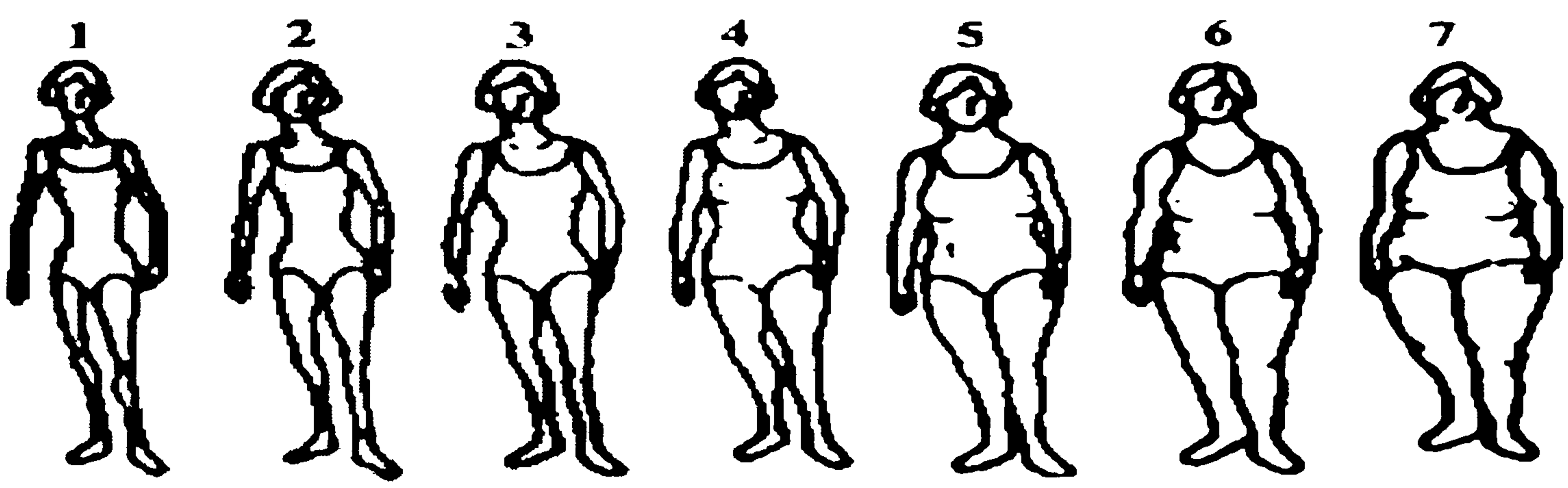
Table 5.57 presents proportions of adolescents' ideal body shape according to their BMI-determined weight status category. It should be noted that only 7 of the 9 silhouette figures are presented; this is because the reported adolescents' perceptions were located between these 7 figures.

There seemed to be a general agreement among boys to select figures between 5 and 6 as their ideal body shape, whereas the majority of girls choose figures between 4 and 5. In both sexes, actual weight status seemed to have little effect on the adolescents' preferences of body shape. About 10% of girls considered the very thin body sizes (body size 1 and 2) as their ideal body image compared to only 2% among boys. More boys (6%) than girls (<1%) selected the heavy body sizes (body size 6 and 7).

Table 5.57. Percentages of adolescents' ideal body figure by actual weight status category



Actual wt status*	%	%	%	%	%	%	%
Under wt (27)	0.0	0.0	7.4	40.7	44.4	3.7	3.7
Normal wt (148)	1.4	2.0	10.1	27.7	50.7	6.8	1.4
Over wt (33)	0.0	0.0	18.2	42.4	39.4	0.0	0.0
Obese (41)	0.0	0.0	17.1	34.1	46.3	2.4	0.0
Total (249)	0.8	1.2	12.0	32.1	47.8	4.8	1.2



Actual wt status*	%	%	%	%	%	%	%
Under wt (9)	0.0	11.1	11.1	55.6	22.2	0.0	0.0
Normal wt (148)	1.4	10.8	45.3	35.8	6.8	0.0	0.0
Over wt (48)	2.1	10.4	31.3	56.3	0.0	0.0	0.0
Obese (52)	0.0	0.0	30.8	44.2	23.1	1.9	0.0
Total (257)	1.2	8.6	38.5	42.0	9.3	0.4	0.0

* Based on the BMI for age percentile classification. Underweight <5th, normal weight ≥ 5th to < 85th, overweight ≥85th to< 95th, obesity >95th percentile (Must *et al*. 1991).

5.6.2 Adolescents' attitudes to body weight

In order to determine the relationship between adolescents' attitudes to body image and BMI, adolescents were asked about how they felt about their current body weight (content / discontent / never thought about it) and whether they had done anything to lose weight (yes / no). Table 5.58 shows the adolescents' attitudes to body weight in relation to their actual weight status. More girls (51%) than boys (32.5%) reported being discontented with their current body weight ($P<0.001$). Approximately 15% of the adolescents admitted that they had never thought about their body weight in terms of being contented/discontented. Despite reporting no concern regarding body weight, 28% of the boys and 41% of the girls in this group were actually overweight or obese. Most of the adolescents who reported dissatisfaction with body weight were overweight or obese (58% of boys and 59% of girls), but considerable proportions were of normal weight (37% of boys and 39% of girls).

Table 5.58. Adolescents' attitudes to current body weight by actual weight status

Actual weight status*	Adolescents' attitudes to current body weight			
	Content (%)	Discontent (%)	Never thought about it (%)	Total (%)
Males				
Underweight	14 (10.9)	4 (4.9)	9 (22.5)	27 (10.8)
Normal weight	98 (76.6)	30 (37.0)	20 (50.0)	148 (59.4)
Overweight	12 (9.3)	15 (18.5)	6 (15.0)	33 (13.3)
Obese	4 (3.1)	32 (39.5)	5 (12.5)	41 (16.5)
Total (%)	128 (51.4)	81 (32.5)	40 (16.1)	249 (100.0)
Females				
Underweight	4 (4.7)	2 (1.5)	3 (7.6)	9 (3.5)
Normal weight	76 (88.3)	52 (39.4)	20 (51.3)	148 (57.6)
Overweight	4 (4.6)	34 (25.7)	10 (25.6)	48 (18.7)
Obese	2 (2.3)	44 (33.3)	6 (15.4)	52 (20.2)
Total (%)	86 (33.5)	132 (51.4)	39 (15.2)	257 (100.0)

* Based on the BMI for age percentile classification: Underweight <5th, normal weight≥ 5th to <85th, overweight ≥85th to <95th, obesity ≥95th percentile (Must *et al*, 1991).

In response to the question "have you done anything to lose weight", 42% of the males and 62 % of the females reported that they had done so (Table 5.59). Of these more than half (55% of boys and 52% of girls) were either overweight or obese. A significant proportion of those boys and girls who reported attempts to lose weight were of the normal weight category (44% of boys and 48% of girls).

Table 5.59. Adolescents' body weight control behaviours by actual weight status

Actual weight status*	Have you done anything to lose weight?		
	Yes (%)	No (%)	Total (%)
Males			
Underweight	1 (1.0)	26 (18.0)	27 (10.8)
Normal weight	46 (43.8)	102 (70.8)	148 (59.4)
Overweight	22 (20.9)	11 (7.6)	33 (13.3)
Obese	36 (34.3)	5 (3.5)	41 (16.5)
Total (%)	105 (42.2)	144 (57.8)	249 (100.0)
Females			
Underweight	1 (0.6)	8 (8.2)	9 (3.5)
Normal weight	76 (47.5)	72 (74.2)	148 (57.6)
Overweight	38 (23.7)	10 (10.3)	48 (18.7)
Obese	45 (28.1)	7 (7.2)	52 (20.2)
Total (%)	160 (62.3)	97 (37.7)	257 (100.0)

* Based on the BMI for age percentile classification: Underweight <5th, normal weight≥ 5th to <85th, overweight ≥85th to <95th, obesity ≥95th percentile (Must *et al*, 1991).

5.6.3 Mothers' perceptions of adolescents' body weight

Mothers' perceptions of their adolescent children's weight were assessed in the case control study. Mothers of obese and non-obese adolescents were asked about how they would rate their children's current body weight (thin, normal and fat) and how they felt about it (content and discontent). Approximately 40% and 31% of mothers of obese boys and girls, respectively, reported their children to be of normal weight (Table 5.60). The rest classified their children as fat. While most of the non-obese adolescents' mothers perceived their children as normal weight (61% in males and 67% in females), more than one third considered their children to be thin (40% in males and 33% in females). None of the mothers in this group perceived their children as being fat. With respect to attitudes to children's current body weight, approximately 30% of obese adolescents' mothers expressed contentment with their children's weight compared to 60% among mothers of non-obese adolescents (Table 5.61).

Table 5.60. Mother's perception of child's current body weight by adolescent's obesity status

Adolescent's obesity status *	Mother's perception of child's current weight			
	Thin (%)	Normal weight (%)	Fat (%)	Total (%)
Males				
Obese	0	17 (39.5)	26 (60.5)	43 (100)
Non-obese	17 (39.5)	26 (60.5)	0	43 (100)
Total	17 (19.8)	43 (50.0)	26 (30.2)	86 (100)
Females				
Obese	0	20 (31.3)	44 (68.8)	64 (100)
Non-obese	21 (32.8)	43 (67.2)	0	64 (100)
Total	21 (16.4)	63 (49.2)	44 (34.4)	128 (100)

* Based on WHO BMI for age and skinfold for age criteria (WHO, 1995)

Table 5.61. Mother's attitude to child's current body weight by adolescent's obesity status

Adolescent's obesity status *	Mother's attitude to child's current body weight		
	Content (%)	Discontent (%)	Total (%)
Males			
Obese	13 (30.2)	30 (69.8)	43 (100)
Non-obese	26 (60.5)	17 (39.5)	43 (100)
Total	39 (45.3)	47 (54.7)	86 (100)
Females			
Obese	20 (31.3)	44 (68.8)	64 (100)
Non-obese	39 (60.9)	25 (39.1)	64 (100)
Total	59 (46.1)	69 (53.9)	128 (100)

* Based on WHO BMI for age and skinfold for age criteria (WHO, 1995)

In summary, more than half of the girls and about one third of the boys expressed discontent with their current body weight. This was consistent with the observation that over 60% of females and 40% of males attempted to lose weight. Approximately one third of obese adolescents' mothers reported their children to be of normal weight and about one third expressed contentment with their children's weight.

CHAPTER VI: DISCUSSION

Obesity is a major health problem facing the world today. It is increasing at an alarming rate in many countries and is affecting people of all ages. Obesity in children and adolescents is particularly serious since overweight children are more likely to become obese adults. In addition, obesity early in life is associated with a wide variety of metabolic abnormalities and increased risk of diabetes, CVD and many other chronic diseases (Must & Strauss, 1999).

The causes of childhood and adolescent obesity are largely unknown. The increasing trends of obesity observed in many industrialised societies and in countries undergoing rapid economic transition over the last decade or so suggest that obesity is a product of complex interactions between genetic and environmental factors. This is because significant changes in the population genetic makeup alone could not have occurred in such a short time (WHO, 2000). The environment may contribute to weight gain through promoting behaviours that favour high energy intake and low energy expenditure, whereas the genetic makeup of an individual determines the strength of the physiological defence mechanisms against shifts in the energy balance caused by such environment.

Among the countries that have experienced rapid socio-economic and lifestyle changes are the Arab Gulf States. This was mainly due to the oil boom of the 1970s and the resultant sharp increase in income. With affluence, new patterns of food consumption and social practices have emerged which are characterized by a shift from the traditional diet (which consists mainly of fish, rice and vegetables) towards a more westernised diet, as well as adoption of a sedentary lifestyle. These factors are believed to have contributed to rising levels of obesity and overweight, and consequently new trends of disease (Musaiger, 1993). Rates of mortality and morbidity due to infectious diseases and under-nutrition have decreased, while those due to chronic non-communicable diseases such as cardiovascular diseases, diabetes, hypertension and cancer have increased. Estimates of the prevalence of overweight and obesity in adolescents vary in different Gulf countries, but in general they are similar to or even higher than those reported in many Western Countries (Table 2.2).

6.1 PREVALENCE AND CHARACTERISTICS OF OBESITY IN BAHRAINI ADOLESCENTS

In this study, a population representative sample of 506 male and female Bahraini schoolchildren between the ages of 12 to 17 years was selected from the four governorates of Bahrain using a multi-stage random sampling technique. The sample represents about 1% of the total number of students in the intermediate and secondary levels of the Government schools in Bahrain.

The classification of weight status among the study participants was determined using the criteria of the WHO Expert Committee (WHO, 1995). Previous studies on Bahraini children and children from other Arab Gulf countries have estimated overweight and obesity using the 85th and 95th percentile of BMI for age. Thus to allow for comparison with these reports we have also used these BMI cut-offs (Must *et al.*, 1991) to define overweight and obesity in the sample of Bahraini adolescents. Additionally estimates of overweight and obesity were presented using the BMI cut-off points of the IOTF (Cole *et al.*, 2000). The results showed that more than half of the Bahraini adolescents (59% of boys and 58% of girls) were of normal weight (≥5th to <85th percentile of BMI for age) whereas 11% of the boys and 3.5% of the girls were in the underweight category (<5th percentile). These estimates were in agreement with studies done in Kuwait (Al-Mousa & Parkash, 2000) and Saudi Arabia (Abahussain *et al.*, 1999). Regarding the prevalence of overweight and obesity, our data showed that 8% of the boys and 3.5% of the girls were overweight and that 21% and 35% were obese, respectively, according to the WHO criteria. Compared to previous reports in Bahrain, the observed levels of obesity appear to be high, even though it is difficult to make such a comparison (Musaiger *et al.*, 1993; Blair & Gregory, 1985). This is largely due to differences in criteria used to define overweight and obesity as well as the different age range of cohorts included in these studies. One exception, however, was a study on Bahraini girls by Musaiger *et al.* (2000a), which was based on data collected in 1992. Compared to that study the present findings showed a remarkable decline in overweight and an increase in obesity among girls, using the same reference data (Must *et al.*, 1991). The prevalence of overweight for the same age group (12-17 years) was 36.5% in 1992 and declined to 18.7% in this study, whereas that of obesity was 7% and increased to 20.2%. These observations suggest a trend of greater fat accumulation in adolescent girls during the 1992-2000 period. Furthermore, since the changes with time observed in these estimates were not in the same direction (i.e. overweight decreased while obesity increased), it is possible that a shift affecting mainly the upper part of the BMI distribution has occurred, causing more overweight girls to become heavier and therefore obese. Troiano and Flegal (1998) found that most of the rise in the prevalence of obesity among US children and adolescents during the last three decades (period between NHES and NHANES III surveys) has occurred among the heaviest group of the population.

The high rate of obesity in the adolescents of this study was consistent with that seen among other age groups in Bahrain, such as primary school children (Al-Aboudi *et al.*, 1995) and adults (Musaiger & al-Roomi, 1997; al-Mannai *et al.*, 1996). Compared with other countries, the increased prevalence of obesity observed was in line with reports from Kuwait (Al-Mousa & Parkash, 2000) and Saudi Arabia (Al-Nuaim *et al.*, 1996b; Abahussain *et al.*, 1999), but was higher than that seen in some Western Countries such as the USA (Troiano & Flegal, 1998). It has been suggested that abundant supply and easy access to high calorie foods, and reduced physical activity associated with the rapid socio-economic transitions in this part of the world have all contributed to the increasing prevalence of obesity (Musaiger, 1993).

6.1.1 Comparison of overweight and obesity prevalence estimated by three different sets of criteria/standards

Despite the different estimates of the prevalence of overweight and obesity obtained by the three sets of criteria used in the present study, the findings indicate a high prevalence of obesity and overweight among adolescents in Bahrain (Table 5.16). While obesity in the teenagers was highest when the WHO recommended criteria were applied, Must *et al's* and the IOTF standards yielded somewhat similar but lower estimates than those calculated using the WHO standard. These findings were not entirely unexpected and appear to be related to differences in the anthropometric indicators, cut-off points and reference data used, as well as differences in the statistical approaches on which these three methods are based. The WHO recommended criteria, for example, use a composite measure of skinfold for age and BMI for age, whereas both Must *et al*'s and the IOTF methods are BMI based standards. It is well known that different anthropometric indicators provide substantially different rates of obesity in youth (Marshall *et al.*, 1991). Skinfold thickness, for example, gives higher estimates of obesity than measures based on weight and height. Furthermore, the reference data published by Must *et al* were derived from the US NHANES 1 surveys, whereas those of the IOTF were derived from pooled international data from six different countries, as well as being based on an entirely different approach in relation to determining BMI cut-off values.

Recently, Flegal *et al.* (2001) compared the prevalence of overweight and obesity in US children and adolescents calculated using the CDC-US growth charts, IOTF standard and Must *et al*'s standard. They found that these three methods did not give similar prevalence estimates and that the IOTF standard produced higher estimates of overweight and obesity in adolescents than the standard of Must *et al.* In this study, a similar tendency for the IOTF method to give higher estimates than Must *et al's* standard was noted, but only for the prevalence of overweight. The variability observed among the three sets of criteria underscores the need for establishing common and uniformly accepted criteria for overweight and obesity in children and adolescents.

Although BMI is not an exact measure of body fat, BMI for age-based standards such as that of Must *et al* or IOTF appear to be more preferable to use than skinfold based criteria. Skinfold thickness measurements are subject to considerable inter and intra-observer error, whereas measures based on height and weight are simple to obtain in a wide variety of settings as well as being reliable (Himes, 1989). This is particularly relevant to developing countries, including the Arab Gulf countries, where skinfold measurement may be difficult to apply on girls and women, because of cultural considerations. Furthermore, the high subcutaneous fat store observed among the adolescents of this study is a cause of concern since it is known that the reliability of skinfold measurement decreases as body fat increases. In this study we have evaluated the usefulness of BMI as a predictor of relative obesity in adolescents. BMI showed a high correlation with percent body fat in both genders independent of age (r=0.932 in boys and 0.921 in females, $P<0.001$), suggesting that BMI is a useful indicator of fatness in the adolescent Bahraini population.

6.1.2 Anthropometry

Anthropometry is widely used in surveys as an indicator of nutritional and health status. It is especially important during adolescence as it allows evaluation of physical and maturational growth as well as health risks during this critical period of development. The finding of this study that weight and height increased with increasing age is consistent with biological processes in adequately nourished children. Bahraini adolescents showed a better growth pattern than previously reported. Compared to a national survey conducted in 1986 on school children between 6 and 18 years of age (Musaiger *et al.*, 1989), our results showed a marked increase in the mean height and weight of adolescents of both sexes and at all ages. It is expected that with improvement of health services, food availability and nutrition awareness that the new generation would be taller and heavier than its predecessors. When compared to the growth of adolescents in other Arab Gulf States, Bahraini girls were very similar to Saudi girls in weight and height (Abahussain *et al.*, 1999), but Bahraini boys were taller and heavier than Saudi boys (al-Nuaim *et al.*, 1996b). In comparison with adolescents from Western countries, Bahraini teenagers were shorter and of similar weight or even heavier than their American counterparts (CDC, 2000). Population variations in growth are the result of interaction between genetic and ethnic factors as well as a variety of environmental influences including socio-economic conditions and nutritional and health status.

The data of the present study showed that all anthropometric measurements and body composition parameters that were related to or indicative of obesity were high. Mean BMI, skinfold thickness and percent body fat were all higher than those reported in earlier studies on Bahraini children of corresponding age range, indicating a secular trend of greater fat accumulation among the adolescent population that appeared to have occurred during the last two decades in this country (Musaiger *et al.*, 1989; Musaiger & Gregory, 2000; Musaiger *et al.*, 2000a). In general, adolescents' BMI mean values were consistent with those of Kuwaiti (Al-Mousa & Parkash, 2000), but higher than those of Saudi (Abahussain *et al.*, 1999) and Omani children (Musaiger, 1994a). Kuwait has a higher level of socio-economic conditions and urbanization. It also has one of the highest rates of obesity in the world (WHO, 2000). Comparison with BMI data from Western Countries, such as the American CDC BMI charts (CDC, 2000) revealed an even greater trend of obesity in Bahraini adolescents, especially among girls. For most age categories, median BMI values of Bahrain boys were above the 50th percentile while those of girls exceeded the 75th percentile of the American reference.

Adolescent girls of this study had higher mean BMI values than boys at all ages, and this was reflected by the finding that obesity was more prevalent among girls than in boys, irrespective of the criterion used to define weight status. Previous studies from the Gulf region have documented a similar sex difference in BMI both in adolescents (Musaiger *et al.*, 1993; Al-Mousa & Parkash, 2000) and in adults (al-Mannai *et al.*, 1996; Musaiger & al-Roomi, 1997). Age and sexual maturation are important factors producing variations in BMI. Several investigators have suggested that the BMI-body fat relationship is affected by sexual maturation to a greater extent than by chronological age (Daniels *et al.*, 1997; Bini *et al.*, 2000). Our data showed that most of the obesity (BMI ≥95th) occurred at age 14 years in boys (25%) and at age 15 years in girls (29%). One of the limitations of the present study, however, is lack of information about the maturational status of Bahraini teenagers. Although it was clear from the beginning (study design stage) that pubertal status would be difficult to determine, due to various cultural and technical constraints, the lack of such important information makes it very difficult to interpret the anthropometric data and the observed trend of increased fatness among the Bahraini adolescents.

In this study the sex-specific equations of Slaughters *et al.* (1988), which depend on skinfold thickness measurements were used to estimate percent body fat in the adolescents. These equations are based on the multi-compartmental model of body composition, which takes into account variations in fat free mass density that occurs as a result of children's growth. Cross-validation studies have yielded acceptable estimates of body fat calculated by these equations (Wong *et al.*, 2000; Janz *et al.*, 1993). However, it has been suggested that predictive equations of body compositions tend to provide less accurate estimates of body fatness when used on a population which is not ethnically similar to the one from which they were derived (Lohman, 1992). Having this in mind, and since equations of body fatness that are specific for the Arab adolescent population are not available, we have used the equations of Slaughter *et al.* (1988) only to obtain a general idea of the extent of excess adiposity in Bahraini boys and girls. The reproducibility of the skinfold measurements used to derive percent body fat was determined by calculating the inter-and intra-observer technical error of measurement (TEM). The results of the reliability analysis showed that the TEM values for skinfold measurement were within the acceptable range as determined by the sex and age specific reference data of Ulijaszek and Lourie (1994) (see Appendix 5).

Our results showed that mean percent body fat was 22.4% in boys and 37.5% in girls. According to the body fat classification of Williams *et al*, (1992), more than one half of the girls and about one third of the boys were in the high-risk category for percent body fat (i.e. percent fat ≥25% in boys and ≥30% in girls). Our data also showed high mean values for triceps and subscapular skinfolds. For instance compared to the US data of NHANES-1 (Must *et al.*, 1991), boys' median values of triceps skinfold were above the 50th percentile of the American reference, whereas girls' values exceeded the 85th percentile of the same reference. A similar picture was found with other anthropometric fat indicators such as the arm fat area.

The results of the study showed a characteristic sexual dimorphism in the anthropometric and body composition indicators of Bahraini adolescents. While BMI and percent body fat increased progressively with age in girls, there was a transient decline in percent of body fat in boys, which occurred at age 15 years. Lean body mass, however, continued to show a steady increase with age in boys. These observations were consistent with the findings of Schaefer *et al.* (1998) who have documented a similar pattern of fat accumulation in a cross-sectional study on German adolescents in whom pubertal development was assessed. Percent body fat was markedly lower in peri-pubertal boys than in pre- or post-pubertal boys. The existence of a sharp decrease in fat accumulation in boys has also been demonstrated in longitudinal studies of skinfold thickness (Gasser *et al.*, 1993). Although it is difficult to speculate about the causes of these trends seen in the body composition of the Bahraini adolescents as they were observed in a cross-sectional study, it is possible that sexual maturational changes in body fat content and lean body mass are responsible for them. Sexual development is an important factor influencing anthropometric measurements and body composition during adolescence (WHO, 1995). In the present study, however, pubertal staging was not performed due to cultural considerations. A previous study in which puberty was determined indirectly (by questioning girls about age of menarche and attainment of adult voice in boys) has found that the mean age of puberty in Bahraini boys was 14.6 years and that of menarche in girls was 13.0 years (Musaiger *et al.*, 1993). If these estimates were correct then it would be tempting to speculate that the drop in body fat observed at age 15 years in the boys of this study reflects puberty–induced changes in fat accumulation. During adolescence, sex differences and age variations in fat mass, fat free mass and regional body fat distribution become apparent. While body fat increases till the age of 17 years in girls, it starts decreasing at the age of 13 years in boys. Conversely, lean body mass increases steeply up to the age of 19 years in boys whereas in girls it stops increasing at age 15 years (Rolland-Cachera, 1993). It has been suggested that the rising level of sex hormones during puberty may contribute to the changes in body composition and regional fat distribution, as these changes coincide with peak height velocity of the growth spurt, which in turn is believed to be mediated by the androgen-dependent increase in growth hormone release (Rogol, 1994). More recently a sex dimorphism in leptin levels, which is related to the gender-specific changes in body composition has been shown to exist in adolescents, suggesting a role for leptin in signalling the initiation of puberty (Ahmed *et al.*, 1999).

6.1.3 Body fat distribution

Waist to hip circumference ratio, waist circumference and subscapular to triceps skinfold ratio are important anthropometric indicators of regional body fat distribution, and high values of these measurements are associated with greater android (central) obesity and possibly higher intra-abdominal fat accumulation. Our results showed that approximately one third of the adolescents had WC measurements indicative of high trunk fat mass, based on the sex and age-specific-cut-offs of Taylor *et al.* (2000). Studies have shown that central fat distribution in adolescents is associated with a variety of metabolic disturbances including elevated blood pressure, increased insulin resistance and hyperinsulinemia as well as increased plasma TG and LDL-C, and decreased HDL-C (Freedman *et al.*, 1999b; Daniels *et al.*, 1999; Gillum, 1999). Gender-specific patterns of fat deposition become established during puberty and appear to be influenced by sex hormones. The finding of this study that boys had higher WHR values than girls was consistent with previous reports (Martinez *et al.*, 1994; Weststrate *et al.*, 1989) and reflects a more centralized fat distribution in boys. The lack of clear trend in the WHR with age was probably due to individual variations in pubertal stage, as sexual maturation has a strong effect on WHR (Martinez *et al.*, 1994). However, data for STR revealed a sex specific pattern which was similar to that described by Rolland-Cachera *et al.* (1990). There was a marked increase in STR in boys, which began at age 13 years and continued till it reached maximum level at age 15 years. In girls, however, no significant variation in STR with age was observed. During adolescence, boys experience a rapid loss of subcutaneous fat at the extremities and an increase in truncal fat accumulation resulting in elevated trunk/limb skinfold ratio, whereas in girls the trunk/extremity skinfold ratio does not change much, as both skinfolds increase in a corresponding fashion (Rolland-Cachera, 1993).

6.1.4 Association of fatness with other health-related risk factors

The relation between obesity in adolescents and CVD risk factors such as hyperlipidemia, hypertension, and abnormal glucose tolerance has been reviewed in the literature (Strauss, 1999; Must & Strauss, 1999). Excessive fatness, whether assessed by skinfold thickness or BMI, has been shown to have an adverse impact on blood pressure, insulin level and serum lipoproteins in children and adolescents (Gortmaker *et al.*, 1987; Srinivasan *et al.*, 1996; Williams *et al.*, 1992). The data of this study showed a strong association between percent body fat and factors considered indicative of greater risk to health/CVD. Boys and girls with elevated SBP were nearly 3 and 4 times, respectively, more likely to have percent body fat at or exceeding the high risk threshold than those with normal SBP. Analysis of the data showed that all adolescents who reported having diabetes were in the high percent body fat category. Although the type of diabetes (i.e. type 1 or type 2 (NIDDM)) was not ascertained in participants, the prevalence of NIDDM among adults in Bahrain is high, and reports from the United States indicate that the incidence of the disease is increasing among adolescents, especially obese adolescents (Dabelea *et al.*, 1999; Pinhas-Hamiel *et al.*, 1996). Body fat was also found to be strongly associated with other anthropometric measurements such as WC ($P<0.001$) and WHR ($P<0.001$) but not with STR ($P>0.05$), in both genders. Moreover, about 32% of the boys and 60% of the girls had percent body fat that would put them in the high-risk category for CVD. A similar pattern of associations was observed when BMI percentile category was employed to assess the relationship between fatness and SBP, DBP, and the occurrence of diabetes, indicating that obesity is a significant factor associated with CVD risk in Bahraini adolescents.

In summary, the findings of the present study revealed that Bahraini adolescents have a high level of adiposity, whether assessed by BMI, skinfold thickness or percent body fat, compared to their counterparts in the Western countries. In addition, our data document a secular trend of increasing obesity in Bahraini adolescents, which appears to have occurred over the last decade and a half.

6.2 DETERMINANTS OF OBESITY IN BAHRAINI ADOLESCENTS

As in adults, childhood and adolescent obesity is a consequence of positive energy balance, which over time leads to a gradual but persistent accumulation of excess fat in adipose tissues. Both genetic and environmental factors appear to be important in the aetiology of obesity. Studies indicate that parental obesity is a key risk for childhood obesity (Maffeis *et al.*, 1998) and that a significant percentage (30%-50%) of the inter-individual variability in BMI is attributable to genetic factors (Bouchard *et al.*, 1998). However, in order for an individual's susceptibility genes to be fully expressed, certain environmental influences that have the potential of causing shifts in the energy balance equation must also exist. Among the environmental factors that have been implicated in childhood and adolescent obesity is physical inactivity and increased energy intake. Other associated factors include age and sex, socio-economic status, perinatal factors, parental obesity and the family environment. This section discusses the relationship between these factors and the risk of obesity among Bahraini adolescents based on the findings of the present study.

6.2.1 Socio-demographic factors

Sex and age are important factors influencing variations in the dietary habits and physical activity behaviours and consequently the weight status of adolescents. However, inconsistencies regarding gender differences in the prevalence of childhood and adolescent obesity have been reported. Some investigators have found a higher prevalence of overweight and obesity among girls (Hanley *et al.*, 2000), whilst others have indicated that the prevalence was higher among boys (Bellizzi *et al.*, 2001; De Vito *et al.*, 1999). In the present study, obesity was higher among girls than in boys, irrespective of the criterion used to assess the weight status. Although no significant association was found between obesity and age in both sexes, there was a tendency for obesity to increase with increasing age in females, whereas in males it tended to decrease with age. Studies on adult obesity in Bahrain have shown that women were more prone to obesity than men (Musaiger *et al.*, 2000b; Al-Mahroos & McKeigue, 1998). Thus the problem appears to start at a young age. Previous work on Bahraini adolescents (Musaiger *et al.*, 1993) and adolescents from other Arab Countries (Mokhtar *et al.*, 2001; Abahussain *et al.*, 1999; Al-Mousa & Parkash, 2000) have documented a similar age and sex trend of obesity to that observed in this study. Differences in fat accumulation associated with growth and puberty may be responsible for the higher prevalence of obesity among girls. Socio-cultural factors may also exert a differential influence on the BMI of adolescents. In Bahrain, for example, as boys get older they become more engaged in outdoor activities such as participation in sports clubs and other social events, which gives them greater opportunities to become physically active, whereas girls, because of the social customs, tend to spend most of their leisure time indoors engaging in more sedentary types of activities.

Socio-economic status is a major determinant of obesity both in adults and in children. The nature of the relationship between SES and obesity varies in different countries. In many developing societies, SES has been shown to be directly related to obesity, whereas in developed countries, an inverse relationship has been reported (Sobal & Stunkard, 1989). Obesity in schoolchildren is strongly linked to the family's socio-economic status (Power & Parsons, 2000; Rolland-Cachera & Bellisle, 1986). Family income, parents' occupation and level of education are all significant predictors of weight status as they influence the child's energy intake and physical activity. In this study, SES was based on parents' education and occupation. The results revealed a strong and direct relationship between mothers' education and girls' BMI status. These findings were further confirmed by the results of the family environment study, which showed that obese adolescents were more likely to be the children of highly educated mothers and fathers with non-manual jobs (i.e. professionals, civil servants and in private businesses) than the non-obese. These results were consistent with earlier studies on Bahraini primary school children (Al-Aboudi *et al.*, 1995) and adults (Al-Mahroos & McKeigue, 1998; Musaiger *et al.*, 2000b).

The findings of the cross-sectional study showed that the mother's educational qualification was significantly and directly related to obesity in girls but not in boys. In contrast, Musaiger *et al.* (1993) found that the mother's education was positively associated with obesity in adolescent boys, whereas in girls no significant relationship with obesity was observed. A possible explanation for this discrepancy between the two studies is that in Musaiger *et al'*s study the definition of parents' educational status was based on a rather broad dichotomous category, "illiterate" and "literate". If the educational level were defined in a more detailed manner, as was carried out in the present study, it is possible that a different pattern of association might have emerged. In addition, the age range of the subjects in the two studies was different, as well as the criteria used to assess obesity in the adolescents.

Social and cultural factors may influence the eating patterns and physical activity behaviour of the children and adolescents in many ways. Adolescents born to a privileged social class may eat more calorie-dense foods. They may also have more pocket money to buy sweets and snacks. In addition, affluent families in Bahrain usually depend on housemaids to perform house chores, which in turn may deprive the children from the minimal form of physical activity that helping around the house can provide, especially if they do not practise any kind of sport. This was supported by our finding that the availability of domestic help in the household was associated significantly with obesity in the adolescents, independent of the mother's education and obesity status.

6.2.2 Dietary habits and behavioural factors

In the present study, energy intake from habitual diet was not assessed. This was largely due to lack of food composition tables that include common local dishes and ready-made foods in the Gulf region, as well as to the difficulty of estimating portion size as most Bahraini families eat together from the same plate (Musaiger, 1987). Unfortunately data on the intake of nutrients in Bahrain are scarce or non-existent. The only available information is that published by the Food and Agriculture Organization (FAO, 2000) on the per capita consumption of fat and energy in some Arab Middle Eastern Countries, excluding Bahrain (Table 6.1). Since the socio-economic factors and dietary habits in Arab Gulf countries are relatively similar (Musaiger, 1987), data from Kuwait, Saudi Arabia and the United Arab Emirates may provide a general idea of the situation of food and nutrition in Bahrain. The daily per-capita energy intakes in the Gulf countries range from 2783 - 3390 Kcal while that of fat range from 79 - 109 grams (percent energy from fat ranges from 26% to 29%). In comparison with figures from other countries, the consumption of fat in the Gulf Region is higher than that in other Middle Eastern Countries, but is less than intakes reported in many western countries.

In the absence of specific information on habitual nutrient and energy intake it is difficult to assess the situation of food consumption of the Bahraini population and its relation to obesity. However, a study conducted by Zaghloul *et al.* (1984), in which obese and non-obese Bahraini adolescent girls were compared with regard to dietary intake, showed that obese girls consume significantly more calories, fat and proteins than their non-obese peers. The mean daily intake of energy and fat for the obese girls was 2,529 kcal and 79.2 grams compared to 2,037 kcal and 61 grams for the non-obese (percent energy from fat: 28.2% vs. 26.9%).

Table 6.1. Daily per capita consumption of energy and fat in selected Arab Middle Eastern Countries (1997) and Western Countries (1995)

Country	Calories (Kcal)	Fat (gram)	% Energy from fat (Kcal)
Egypt	3287	58	15.9
Iraq	2619	77	26.5
Sudan	2395	37	13.9
Kuwait	3096	95	27.6
Saudi Arabia	2783	79	25.5
UAE	3390	109	28.9
France*	-	140	-
United Kingdom*	-	140	-
Sweden*	-	130	-

Source: FAO (2000), * Seidell, (1995)

The results of this study showed a picture of strong associations between obesity and eating habits in the Bahraini adolescents. Adolescents who practised eating behaviours which are generally considered to be "unhealthy", such as frequent snacking, skipping breakfast, eating meals while watching TV, distress eating and frequent intake of fast foods, had a significantly higher risk of developing obesity. On the other hand, adolescents who reported healthy eating habits, such as eating with the family members, had a reduced risk of being obese. The data has also revealed a clear gender difference in relation to the pattern of risk associated with these eating behaviours. With the exception of snacking habits, which showed a significant association with BMI status in boys, all of the observed associations between eating behaviours and obesity were found to be statistically significant in females only. While its difficult to explain why such sex differences in eating habits and consequently obesity risk exist among Bahraini teenagers, it is possible that the observed differences reflect a differential influence exerted by the social customs and traditions in Bahrain in relation to the eating behaviours of the male and female adolescents.

Our findings showed that skipping breakfast was significantly related to an increased risk of obesity in female adolescents. The association between breakfast skipping and greater BMI observed in this study and other studies (Guansheng, 2001; Musaiger, 1994a; Summerbell *et al.*, 1996) may reflect a dieting technique practised by these girls, as many overweight girls resort to omitting breakfast as means of losing weight (Bull, 1988). A study from Australia showed that girls were three times more likely to skip breakfast than boys, and that children who skipped breakfast were more likely to be dissatisfied with their weight and to have been on a diet, than those who ate breakfast (Shaw, 1998). Musaiger *et al.* (1991) found that skipping breakfast to help in weight reduction was a widely held belief among females in the Gulf region. It is also possible that girls who skip breakfast tend to consume greater amounts of food at lunch, and thus gain weight.

Frequent snacking is an important feature of adolescents' food habits. The results showed that frequent snacking is a significant independent risk factor for obesity in boys. Types of snacks consumed by the adolescents, and their nutritive value, were not investigated in this study. However, a study in which the caloric and macronutrient composition of snacks and meals consumed by British adolescents were assessed showed that compared with meals, snacks have a relatively high sugar composition and a relatively low fat and protein content (Summerbell *et al.*, 1995). In a study on the dietary habits of Omani adolescent girls, Musaiger *et al.* (1994a) observed a similarity between the snacking habits and food preferences of these girls and those practised by their Western counterparts. Since many snacks have a high caloric content, the direct relationship between frequency of snacking and obesity observed in this study may be indicative of increased energy intake of the adolescent boys. Snacking may contribute to weight gain by providing occasions for consuming energy-dense foods in between meals, as well as by increasing the frequency of such intake. Jahns *et al*, (2001) documented an increase in the prevalence of snacking among US children and adolescents during the 1977 to 1996 period, and concluded that the observed increase in the energy contribution of snacks was mainly due to the increase in the frequency of snacking rather than the size or energy content of the snack. The observation that snacking late at night and in the afternoon was linked to obesity in Bahraini boys but not in girls was not entirely unexpected and appears to be related to the social context in which snacking occurs. Bahraini teenage boys have greater opportunities to go out, especially at night, and purchase snacks as well as eat away from home in cafés and fast food restaurants than girls.

Frequent consumption of fast food has been shown to be associated with higher energy and fat intake in adolescents (French *et al.*, 2001) and with greater weight gain in women (French *et al.*, 2000). Our findings showed that high frequency of eating takeaway fast foods was significantly related to obesity in girls but not in boys. Home delivery fast food restaurants are a growing business in Bahrain and have become very popular in the past few years, especially among the younger generation. While boys can actually go with their friends to these places, girls have to content themselves with making home delivery orders.

The daily consumption of fruits and vegetables is an important indicator of healthy diet. Most fruits and vegetables have low caloric content and are rich in fiber and micronutrients. More than one quarter of the boys and one third of the girls in this study did not eat fruits daily, but no significant association was found between intake of fruits and risk of obesity in the adolescents. A study on Bahraini adults, however, showed that frequent consumption of vegetables was negatively related to obesity, whereas that of fruits was positively related to obesity (Musaiger *et al.*, 2000b).

Family food habits is a major factor influencing a child's energy intake (Feunekes *et al.*, 1998; Birch & Davison, 2001). This includes not only food selection for meals but also the habit of eating meals together with parents and other family members. The results of this study indicated that eating meals together with the family was a significant factor associated with reduced risk of obesity in girls, independent of mothers' education and other related factors. This is consistent with the results of Thakur and D'Amico (1999) who found that obese adolescents were more likely to report infrequent meals with the family than non-obese adolescents. Having meals with the family may provide protection against obesity through reducing frequency of snacking as well as through guarding against eating nutritionally poor calorie-dense foods. Gillman *et al.* (2000) found that eating dinner with the family was significantly associated with healthy dietary intake patterns in US children and adolescents, including greater fruit and vegetable consumption, less intake of fatty foods and soda, and more micronutrient and fiber consumption.

The practice of taking meals in front of the TV has become very popular among Bahraini families in recent years. Family members would usually sit on the floor of the living room and have their meal while the TV is on. Reports from other Arab countries documented a similar trend in eating habits. Yasin (1998) found that 31% of men and 54% of women in Egypt have lunch while watching TV and that the proportions of those practicing this habit were even higher at dinner-time (72% in men and 85% in women). Our data showed that having meals while watching TV had a significant and positive effect on BMI. Girls who frequently took their meals in front of the TV were twice as likely to be obese than those who seldom did so. In boys no such significant association was found. It has been postulated that the direct association between TV and overweight in children and adolescents may be mediated by excessive energy consumption while viewing TV (Dietz & Gortmaker, 1985; Gortmaker *et al.*, 1996). Although it is difficult, in a cross-sectional study, to hypothesise about the sequence of events involved in the causal pathway of the TV-overweight relationship, our results are in support of the hypothesis that TV viewing encourages increased caloric intake, which in turn can, over time, lead to weight gain.

Our data showed that eating when upset, angry or in negative mood (distress eating) was a significant and independent contributing factor to obesity in adolescent girls, but not in boys. Girls who frequently ate while upset or angry were 3 to 7 times more likely to be obese than those who rarely demonstrated this behaviour. These findings were consistent with those of Rasheed (1998) who, in a case control study on Saudi women, observed a significantly greater tendency among obese females to eat under emotional conditions of stress and anger and indulge in binge eating. Obesity and "self" concept have been shown to be associated with dieting (Field *et al.*, 1993) and eating disorders (Vila *et al.*, 1995) in adolescent girls. It has been suggested that psychological distress suppresses eating in unrestrained eaters (non-dieters) but increases eating in restrained eaters (dieters) (Oliver & Wardle, 1999; Wardle *et al.*, 2000). The finding that distress eating was significantly associated with obesity among the girls of this study suggests that obese girls may practice restrained eating behaviour (dieting), which in turn makes them more prone to distress-induced overeating. This is consistent with our observation that 83% of the obese girls reported previous attempts to lose weight compared to only 49% in the non-obese group (P=0.000). However, since information regarding methods used to lose weight was not collected, it is difficult to speculate about the dieting behaviour of Bahraini girls.

6.2.3 Physical activity behaviours

Physical inactivity and sedentary living are becoming increasingly prevalent and have been suggested as important factors contributing to the global increase in rates of obesity in many countries (WHO, 2000). In children and adolescents, maintaining an optimal level of physical activity is particularly important, as it not only reduces risk of overweight but also improves body composition and growth pattern (Deheeger *et al.*, 1997). Among behaviours related to physical activity examined in this study, to determine whether they were associated with risk of obesity in the adolescents, are walking/cycling to school, playing sport outside school, participation in school PE and the amount of time spent watching TV and in other sedentary activities.

The results showed a strong association between physical activity behaviours and obesity in Bahraini adolescents. Boys who walked or cycled to school had a significantly lower risk of obesity than those who travelled to school by other means. In girls, however, although a similar trend was observed, the association was not statistically significant. The role of physical activity in the development of obesity has been studied extensively. Results from cross sectional studies (Wolf *et al.*, 1993; McMurray *et al.*, 2000; Hernandez *et al.*, 1999) and from longitudinal studies (Kemper *et al.*, 1999; Berkey *et al.*, 2000) on children and adolescents support the existence of a negative relationship between obesity and physical activity. The finding of this study that the vast majority of adolescents rely on motorised transport to travel to school is consistent with the low level of physical activity in Bahraini adults (Al-Mahroos & McKeigue, 1998). Musaiger and Al –Roomi (1997) found that only 13% of the men and 8% of the women in Bahrain exercise regularly. In a study investigating factors contributing to obesity among adults, Al-Mannai *et al.* (1996) found that ownership of a car was strongly related to increased risk of obesity in Bahraini men and women. The rise in the standards of living and advances in technology and transportation have affected many aspects of people's life including their physical activity level. Today Bahraini people, adults and children alike, have little or no physical activity in their daily lives. Walking to school, workplace or to shops has become increasingly rare and people often use their cars even for the shortest distances. Facilitating this trend is the hot humid climate of the Gulf Region, which makes walking very difficult, especially in the summer months.

The results of the present study revealed a significant and negative relationship between playing sport outside school and risk of obesity in the teenagers. The relationship persisted after controlling for many of the recognised variables that affect the prevalence of obesity among the Bahraini adolescents. Playing sport after school hours was associated with a 60% and 70% reduction in the risk of developing obesity in the boys and girls, respectively. These observations were consistent with the results of Zaghloul *et al.* (1984) who compared the physical activity level of obese and non-obese Bahraini female adolescents and found that obese girls were significantly less active than non-obese girls. Similar findings were reported in school children in UAE (Moussa *et al.*, 1994b). The data revealed that a considerable proportion of Bahraini teenagers (44% of boys and 71% of girls) do not practise any kind of physical activity outside school. A study, in which barriers to practising exercise and sport in Bahraini women was investigated, showed that 79% of the females studied perceived lack of facilities and special clubs for women to be the main reasons for not indulging in physical exercise (Al-Amer, 1996). Our finding that playing sport outside school had a protective effect against obesity, emphasises the importance of encouraging adolescents to exercise during leisure time by providing and improving access to sport facilities such as local clubs and community recreational centres. This is particularly important for girls, as fewer opportunities may exist for them to participate in organised sport and competitive games, or engage in physical activities through outdoor playing, than boys. The observation that Bahraini boys had a higher level of participation in sport than girls was in line with the gender differences in levels of physical activity reported in the literature (Gordon-Larsen *et al.*, 1999; Taylor & Sallis, 1997). Greater physical activity participation in boys may be related to differential development of motor skills and differences in body composition associated with biological maturation (Kohl & Hobbs, 1998), as well as psychosocial factors (Craig *et al.*, 1996).

Participation in the school physical education programme showed no significant association with obesity in the adolescents. However, studies on adolescents from other countries have shown that participation in school PE was associated with a significant improvement in the physical activity level (Gordon-Larsen *et al.*, 2000; Luepker *et al.*, 1996) and BMI (Lionis *et al.*, 1991) among students. The lack of association between participation in PE classes and weight status in Bahraini adolescents appears to be due to low variability in the students' responses, as participation in school PE classes is compulsory, especially for students in the intermediate level. These findings suggest that PE classes may represent the only opportunity available for girls to engage in regular physical activity. Unfortunately school PE programmes in Bahrain suffer from major weaknesses, both in terms of the amount of allocated PE time as well as the quality of the programme offered. A study conducted on adolescent school boys in Saudi Arabia, which has a similar PE system, and in which heart rate monitoring was used during PE lessons showed that the actual time of PE was 32 minutes and that the mean time spent in moderately intense activity was 12.6 minutes (Al-Hazzaa & Almuzaini, 1999).

It has been suggested that the rise in rates of overweight among children and adolescents observed in some developed countries may be due to physical inactivity and that this is likely to be a more important contributing factor than increased levels of energy intake (Troiano *et al.*, 2000; Guillaume *et al.*, 1998). One of the most prevalent inactivity behaviours that have been linked to childhood obesity is TV viewing. Several investigators have found that duration and frequency of TV watching was directly related to obesity in children and adolescents (Dietz & Gortmaker, 1985; Andersen *et al.*, 1998; Robinson, 1999). The results of this study showed that hours of TV watching were positively related to risk of obesity among Bahraini boys. The weak relationship observed in girls may be due to errors in self-reports of television viewing time. Boys who watched TV for more than 3 hours per day were three times more likely to be obese than those watching for less than 2 hours a day. However, after controlling for other variables in the multivariate model, the relationship between TV viewing and boys' BMI status disappeared, suggesting that the observed association was due to some other confounding variables. TV viewing is a major recreational activity in the Gulf region (Musaiger & Al-Roomi, 1997). Earlier studies have demonstrated the existence of a significant direct relationship between frequency of TV viewing and BMI status in Bahraini adults (Musaiger *et al.*, 2000b; Musaiger & Al-Mannai, 2000) and in young adults from the United Arab Emirates (Al-Neyadi, 1995).

The analysis of risk of obesity in relation to time dedicated to sedentary activities other than TV viewing (i.e., doing homework, reading and playing video and computer games) showed no significant relationship with obesity in Bahraini adolescents. This was in agreement with the results of Hernandez *et al.* (1999) who found that hours of TV viewing, but not that of VCR or videogames use, was significantly associated with obesity in Mexican children. Unlike other forms of sedentary activities, TV viewing may promote greater energy intake. This can occur as a result of eating food during viewing as well as through being exposed to TV food commercials (Gortmaker *et al.*, 1996). The finding of this study that obesity in boys was associated with hours of TV viewing but not with hours spent doing homework or playing video/computer games suggest that increased energy intake may be the mechanism via which TV viewing can influence the weight status of Bahraini adolescents. Musaiger (2000a) found that more than half of the secondary school girls in the United Arab Emirates frequently eat while watching TV, 41% sometimes and only 6% reported no intake of food while watching TV. The main types of food eaten in these occasions were chocolates, sweets, potato chips, nuts and carbonated beverages. It is possible that a similar pattern of eating behaviour exists in Bahraini adolescents.

It has been suggested that increasing physical activity of children and adolescents provides a better route to reducing rates of overweight and obesity in this age group than decreasing energy intake. This is largely because of the multiple beneficial effects of physical activity, which include body weight regulation, improved growth and body composition, as well as psychological well-being (Goran *et al.*, 1999). In addition, physical activity in childhood is most likely to serve as a basis for future physically active life. The International Consensus Conference on Physical Activity Guidelines for Adolescents recommends that "all adolescents should be physically active daily or nearly every day as part of play, games, sport, work, transportation, recreation, physical education or planned exercise, in the context of family, school and community activities" (Sallis & Patrick, 1994). The National Institute of Health Consensus Conference (NIH, 1996) has also issued a recommendation statement that " Children and adults alike should set a goal of accumulating at least 30 minutes of moderate-intensity physical activity on most and preferably all days of the week".

6.2.4 Perinatal factors

Prenatal life and early postnatal life are important stages of growth and development. It has been suggested that nutritional alterations at this critical period can predispose individuals to obesity later in life (Dietz, 1997), while optimal nutrition, as represented by breastfeeding, can confer protection against overweight during childhood and adolescence (Martorell *et al.*, 2001). This study has attempted to investigate whether early nutrition, assessed by birthweight and breastfeeding, was associated with a risk of obesity in Bahraini adolescents. The results showed no significant association between birthweight or breastfeeding and risk of obesity in the adolescents. Previous work has, however, indicated that low birthweight is a significant predicator of subsequent obesity, although this does not appear to be a consistent finding (see section 3.6.5.). Inconsistencies in the association between birthweight and later fatness may reflect differences in the genetic predisposition to obesity among various ethnic groups or may be due to differences in methodology used. Recently, Stettler *et al.* (2000) examined risk factors present at birth for increased adiposity in adult African Americans and found no significant association between birthweight for gestational age and obesity, after adjusting for maternal pre-pregnancy BMI and other factors. Similarly, Frisancho

(2000) failed to find a significant association between birthweight and adiposity in adolescents and concluded that parental obesity may be a more important factor influencing obesity at this age. The lack of significant association between birthweight and obesity in the present study appears to be the result of inadequate variability in birthweight. As was observed by Dietz (2000), most of the studies that were successful in detecting a significant difference in the risk of obesity have used either low birthweight (<2500 g) or high birthweight (>4000 g) to contrast birthweight categories. In this study, however, we have compared obese and non-obese adolescents with birthweight ≤ 3000 g with those whose birthweight >3000 g. This was mainly because of the low number of subjects at extreme ends of the birthweight distribution. Only 16 subjects (7.7%) had birth weight below 2500g and 8 subjects (3.8%) had birth weight > 4000g. Such a narrow range of data, along with a relatively low sample size, may have resulted in loss of power and consequently a weak birthweight-obesity relationship. Nevertheless, the data revealed a tendency for obese adolescents to have greater birthweight than the non-obese group (OR=1.49, 95% CI=0.83-2.69), suggesting that high birthweight may still be an important factor contributing to the risk of obesity in Bahraini adolescents. Unlike many studies that have relied on self-reported birthweight or birthweight reported by the mother, we have verified reported birthweight against hospital discharge cards/records, which gives some confidence in the trend of association observed, even though it did not reach statistical significance (P=0.150). To our knowledge, this is the first study that has attempted to examine the association between birthweight and obesity in Bahrain. If this study were to be repeated with a larger sample, it is possible that a significant effect may be uncovered.

In addition to its multiple benefits in relation to infant's health, growth and development, breastfeeding has recently been suggested to have a protective effect against the development of overweight and obesity in young children (von Kries *et al.*, 1999) and in adolescents (Tulldahl *et al.*, 1999; Elliott *et al.*, 1997). The results of this study showed no significant relationship between breastfeeding and obesity in the adolescents (OR=0.62, 95% CI=0.34 –1.11). This was in agreement with the findings of Hediger *et al.* (2001) who could not detect a clear effect of breastfeeding on the risk of being overweight in 3-5 year old children. However, another study in which the same relationship was investigated, but in 9-14 years old children, showed that children who were predominantly breastfed during the first six months of life had a significantly lower risk of overweight than those who were predominantly formula fed (Gillman *et al.*, 2001). One difference between this study and the present study, which may account for such a discrepancy in results, is the system used in categorizing breastfeeding. While Gillman and colleagues compared children who were mostly or exclusively fed breast milk with those who were exclusively or mostly fed formula during the first six months of life, the present study compared obese and non-obese subjects for whether or not they were exclusively fed breast milk (i.e. breast milk was the only liquid diet given) during the same period. Because in this study subjects who were exclusively bottle-fed and subjects who were partially breastfed (i.e. received both breast milk and formula) were combined into one group, which was then contrasted with the exclusively breastfed group, it is possible that those adolescents who were partially breastfed were more exposed to breast milk than to formula, which in turn may have reduced their risk of obesity and consequently diluted the overall effect of breastfeeding on weight status. Another difference between the two studies is the size of sample included. While in the present study the relationship was investigated in a sample of 211 adolescents, the large sample size included in Gillman *et al's* study (> 15,000 children) certainly helped to define the effects observed in a more precise manner.

The present study revealed a negative, albeit weak, association between breastfeeding and obesity among Bahraini adolescents, with breastfeeding being less prevalent among the obese group (51%) than in non obese (63%) (P=0.083). This, and the fact that this is, as far as is known, the first study that has attempted to investigate the association between obesity and breastfeeding in Bahrain and possibly in the Gulf region as well, highlight the importance of conducting further studies that include a large sample of children and adolescents, as well as other factors that have been shown to influence feeding patterns during infancy, such as duration of breast feeding and weaning age (time of introduction of complementary feeds), in order to determine whether the protective effects of breastfeeding reported in some developed countries may extend to countries in the Middle East, such as Bahrain.

6.2.5 Obesity in parents and other relatives

The results of the present study indicate the existence of a strong association between parental BMI and risk of obesity in adolescents. In the fully-adjusted multivariate regression model, obese adolescents were 2.6 times more likely to have one obese parent and 5.2 times more likely to have both parents who were obese compared to the non-obese. These results are in good agreement with that reported in Bahraini 15 to 21 year-olds (Musaiger *et al.*, 1993) as well as with those reported in children and adolescents from other countries (Maffeis *et al.*, 1998; Maffeis *et al.*, 1994; Moussa *et al.*, 1994b). Obesity when present in parents not only influences the BMI of the children but also increases their risk of later obesity (Frisancho, 2000; Burke *et al.*, 2001; Whitaker *et al.*, 1997). Familial resemblance in body weight could be due to genetic factors as well as environmental factors, since parents provide both the genetic predisposition and the environment where such predisposition can manifest itself. Thus the significant association observed in the present study between adolescents' obesity and their parents' BMI status might have resulted from shared genes or from shared environmental factors. Family studies that have attempted to quantify the relative contribution of genetic and non-shared environmental factors to the familial resemblance in body weight, showed that the maximal heritability of obesity ranges from 30 to 50% (Bouchard *et al.*, 1998). Studies of twins (Stunkard *et al.*, 1990; Bodurtha *et al.*, 1990) and adopted children (Stunkard *et al.*, 1986; Sorensen *et al.*, 1992) also support a role for genetic factors in the development of obesity. In this study some evidence of a genetic influence was found that might account for similarities in familial obesity. The estimated father-child BMI correlation (0.21) and mother-child BMI correlation (0.38) were significant and comparable to those reported in the literature: r =0.20-0.37 (Fogelholm *et al.*, 1999) and r =0.29-0.44 (Treuth *et al.*, 2001). In agreement with other studies (Williams, 2001; Whitaker *et al.*, 1997), we found that maternal obesity had a stronger influence on the child's BMI than the fathers' obesity. This is not likely to be due to reporting errors, since BMI data for all the mothers and almost all the fathers (96.1%) were based on measured heights and weights, suggesting that maternal factors exert a considerable influence on the heritability of obesity in Bahrain. The BMI heritability index calculated using the Risch's lambda value (λ_R), defined as the risk of being obese, given that one's relatives are also obese, compared to the population prevalence of obesity, in this study was 1.88 for the mother-offspring pairs and 1.42 for the father-offspring pairs. These values were lower than those reported for the mother and child pairs (2.61) and for father and child pairs (2.80) of the United States national survey (NHANES-II), but were similar to those calculated for East Indian parent and offspring pairs (1.60) (Allison *et al.*, 1996). Variations in heritability estimates may be related to differences in genetic and ethnic factors, as well as differences in sample size and age range of subjects.

The present study revealed a strong association between obesity in adolescents and the reported presence of obesity among relatives. Obese adolescents were nearly 3.7, 2.2 and 2 times more likely to have an obese sibling, grandparent and uncle or aunt, respectively, than the non-obese. These results further confirm the familial aggregation of overweight and obesity (Guillaume *et al.*, 1995; Maffeis *et al.*, 1994) and suggest that genetic factors may contribute to the observed trend of familial clustering of obesity in Bahrain. The genes responsible for the development of obesity have been the subject of intensive research during recent years and a variety of single gene mutations that can lead to obesity have been identified in animals and in humans (Perusse & Bouchard, 1999). However, current evidence suggests that the faulty genes in human obesity is a rare phenomenon and that obesity is most likely to be a polygenic condition, which may be affected by various environmental influences (Guillaume & Bjorntorp, 1996).

Parental history of cardiovascular diseases is an important surrogate measure of cardiovascular risk in offspring. Boa *et al.* (1995) found that children and young adults with a positive history of parental heart attack, diabetes or hypertension were significantly overweight, irrespective of age, and had elevated levels of glucose, insulin, total cholesterol and LDL-C, as well as high blood pressure. Our findings (from both the cross-sectional and the case control study) indicated that a parental history of diabetes was a strong and independent predictor of risk of obesity among the adolescents; obese adolescents were 4.8 times and 3.6 times more likely to have diabetic mothers and fathers, respectively, than the non-obese. These results are consistent with those of Srinivasan *et al.* (1996) who found that the risk of becoming an overweight adult was significantly higher among adolescents with a positive parental history of diabetes. Diabetes is a significant health problem in Bahrain, accounting for about 4% of the total deaths in the kingdom (MOH, 1998). The prevalence of diabetes among the Bahraini adult population is 30% (Al-Mahroos & McKeigue, 1998). Parental history of heart disease or hypertension showed no significant correlation with the risk of being obese among adolescent subjects. The reason for this is not clear but the multi-factorial nature of these diseases might have obscured the association. However, previous studies showed that both diabetes and hypertension were significantly related to obesity among Bahraini adults (Musaiger *et al.*, 2000b; Musaiger & Al-Mannai, 2000). Given the familial aggregation of obesity observed in the present study and the importance of parental history as an independent predictor of obesity in this adolescent population, prevention strategies should be planned with particular attention to the subgroup of families with one or both parents with a history of diabetes and/or obesity.

6.2.6 Factors related to the family environment

Familial similarities in eating habits and physical activity may be responsible, in part, for familial patterns of adiposity, and parents may play a significant role in determining the type of environment within the family in relation to obesity among the children (Birch & Davison, 2001). Such parental influence may be exerted through the mother's and father's own eating and lifestyle behaviours and their parenting practices, as well as through controlling the availability and ease of access to food in the house. The results of the study showed that obesity in the adolescents was strongly and positively associated with maternal inactivity behaviours. Compared to controls, obese boys and girls were more than twice as likely to be the off-spring of mothers who did not exercise, watched TV for more than 16 hours a week and had a domestic helper, than the non-obese. These results are consistent with the hypothesis that parents' lifestyle is an important factor influencing the child's weight status (Birch & Davison, 2001). Resemblance between parents and their children in the pattern of physical activity and inactivity is well documented (Sallis *et al.*, 1988a; Sallis *et al.*, 1988b). Fogelholm *et al.* (1999) found that inactivity in parents was a strong and positive predictor of children's inactivity level. Moore *et al.* (1991) found that children aged 4-7 years were more likely to be active if the mother (OR=2.0) or the father (OR=3.5) was active, and that when both parents were active the odds ratio was considerably higher (OR= 5.8). Parents may influence the physical activity behaviours of their adolescent offspring by serving as a role model, as well as by providing encouragement and support (Lau *et al.*, 1990). Recent evidence from family and twin studies indicates that physical activity behaviour is also heritable (Beunen & Thomis, 1999).

It is not likely that the relationships observed in the present study between the mother's lifestyle variables and obesity in the children were due to the mother's obesity or some other confounding variable, since controlling for maternal BMI status and level of education failed to alter these associations. Because of the case control design of the study, it is not possible to be sure that maternal inactivity behaviour predated the obesity problem in these teenagers and therefore might be causally related. However, when taken together with other findings, especially familial clustering of obesity and the negative relationship seen in the cross-sectional study between physical activity behaviour and adolescents' BMI, the observed association between mothers' inactivity and adolescents' obesity suggests that exposure to a family environment which is characterized by a sedentary lifestyle among parents may have favoured the expression of obesity in the Bahraini adolescents. One limitation of the study is that it did not include comparison of parent–child physical activity behaviours, which would have provided a better insight of the parents' influence on their children's weight status. Further research is needed to determine whether parental physical activity and inactivity behaviour is an important modifiable factor of risk for obesity among adolescents in Bahrain.

Several studies have shown that mothers' child-feeding strategies have a significant impact on children's eating style and weight outcome (Birch & Fisher, 1998). Johnson and Birch (1994) found that mothers who were highly controlling of their children's eating often had children who demonstrated less ability to self-regulate their food intake. Greater maternal use of restriction of palatable foods and pressure to eat have also been shown to be related to higher energy intake and BMI in the daughters (Birch & Fisher, 2000; Lee *et al.*, 2001). In contrast, the findings of the present study showed that the mother's degree of control over the child's eating was strongly and indirectly related to a risk of obesity in the Bahraini adolescents, independent of the mother's education or obesity status. Obese adolescents were less likely to be the children of mothers who exercised a high level of control over their children's eating (such as using food as means of reward (OR=0.45, 95%CI= 0.22-0.93) or controlling child's intake of sweets and snacks (OR=0.32, 95%CI=0.17-0.62)). The case-control design of the present study does not allow the causal direction of the relationship observed between adolescents' obesity and parenting style to be ascertained. Nevertheless, it seems likely that the negative association documented here between parental control and adolescents' obesity reflects a consequence rather than a cause of obesity in these teenagers (i.e. because adolescents are already obese, mothers have less need to practise a high level of control to increase their eating). A mother's parenting style is in part a response to the child's weight status. Thus mothers of thinner children may practise child-feeding strategies that would encourage the child to eat more (such as use of food as rewards) whereas mothers of heavier children may resort to restricting a child's access to calorie-dense snacks, or verbally discourage the child's eating of these foods. Other findings from this study provide support for this view. Obese adolescents were more likely to be the children of mothers who would discourage (OR=2.39, CI 1.12-5.13), but less likely to have mothers who would encourage (OR=O.50, CI=0.24-1.06) them to eat certain foods than the non-obese. Obese teenagers also had a significantly higher likelihood (OR=3.94, 95%CI= 2.02- 7.71) of being the children of mothers who would frequently prompt them to exercise.

The fact that this study was conducted on adolescents, whereas almost all of the previous studies that have examined mother–child feeding practices have focused on young children between 3-5 years of age, may account for the apparent discrepancy in findings between this study and previous work. Infancy is the period during which food preferences and eating style are known to develop, and parents, through their own eating behaviour (modelling) and through their child-feeding techniques, can play an important role in determining children's eating behaviours (Birch & Fisher, 1998). However, as children become older, such a role may become less important (Shepherd & Dennison, 1996). Khan (1981) reported that social and external considerations, particularly friends, become increasingly significant influences on eating habits with the transition through adolescence. Our findings that parental control over children's eating was inversely associated with obesity in adolescents, are consistent with the results of Spruijt-Metz *et al.* (2002), who investigated the same relationship in older children (7-14 years of age). Thus it seems likely that age as well as the perceived weight status of the child may be significant factors influencing the way parents treat their children, and that the association between parenting style and risk of obesity previously observed in preschool children may not extend to older children and adolescents.

One limitation of this study is that the hypothesis linking parental influence on child's eating to a child's weight status was not adequately tested on the adolescents. Many of the variables used to assess parental degree of control over children's eating were adapted from similar items in questionnaires that primarily targeted small children, and therefore they may not be relevant to use on adolescents.

In conclusion, the findings suggest that, among 12 to 17-year-old Bahraini adolescents, mothers' child-feeding strategies are largely a reflection of the adolescent's current weight status. It is possible, however, that parenting style may exert a different influence on younger children in Bahrain.

Increased availability and easy access to high-energy food has been suggested as one possible way by which the current environment can promote obesity (Hill & Peters, 1998). The results of this study showed no significant association between availability and accessibility of calorie-dense snacks in the home and the risk of obesity in the adolescents. Similarly the frequency of availability of fruits in the house was not related to the BMI status of these teenagers. Previous studies on young children, however, have demonstrated a significant association between availability and accessibility of foods and children's food intake. Cullen *et al.* (2001) found that food availability was positively associated with fruit and vegetable preferences and intake in school children. Restricting young children's access to energy-dense foods has been shown to enhance children's desire for these foods, as well as over-consumption (Fisher & Birch, 1999). Our inability to detect a significant association between the availability and accessibility of snacks and obesity in adolescent may be explained, in part, by obese teenagers obtaining and eating snacks outside the home. This argument is supported by the finding that obese adolescents had a significantly greater likelihood (OR=3.30, 95% CI=1.82-6.07) of buying their own snacks than the non-obese. Adolescence is a period which is characterised by a greater freedom over what food to eat, where and with whom, and several factors including age and sex, beliefs and mood, as well as family income, appear to influence food choice at this age (Shepherd & Dennison, 1996). Further research is needed to determine whether home availability and ease of access to high fat and high calorie foods is a significant family environmental factor contributing to adolescent obesity in Bahrain.

6.3 BLOOD PRESSURE AND OBESITY

One of the aims of the present study was to investigate the association between obesity and the risk of elevated blood pressure in adolescents in Bahrain. Although the relationship between BMI and BP has been extensively studied, as far as is known, this was the first study to examine this relationship in Bahraini adolescents.

The results of this study demonstrated age and sex differences in the blood pressure of adolescents. As was previously reported (Leccia *et al.*, 1999; Okasha *et al.*, 2000), gender differences were marked for SBP, with boys having higher values than girls, but not for DBP. The finding that the correlation between age and SBP was greater in boys ($r=0.44$, $P<0.001$) than in girls ($r=0.21$, $P=0.001$) appears to be due to gender-related differences in the pattern of growth and increase in height with age. The study revealed several anthropometric variables that were significantly correlated with systolic blood pressure in the adolescents, including height, weight, BMI, percent body fat, FM, WC and WHR. Because of the difficulty in separating the effects of these anthropometric variables on SBP, since they are highly correlated with each other, an attempt has been made to evaluate the independent influence of these variables by multiple stepwise regression analysis, which was done on those variables that showed the strongest correlation with SBP, or have been previously shown to be important in explaining variations in SBP in adolescents. The close relationship between increased body weight and elevated blood pressure have been described in both adults (Berkey *et al.*, 1998) and children and adolescents (Horswill & Zipf, 1991; Wilson *et al.*, 1985). The findings of the present study indicated that weight and height in boys, and weight in girls, were the most important predictors of systolic blood pressure in Bahraini adolescents. The observation that in boys, age and body size account for a greater proportion of SBP variations than percent body fat, was consistent with previous work (Leccia *et al.*, 1999; Stallones *et al.*, 1982), and suggests that body composition components other than body fat (such as muscle and bone mass) may be involved in mediating the relationship between blood pressure and body mass. STR, a widely used indicator of fat patterning, has been shown to be associated with the occurrence of hypertension in adults (Gillum *et al.*, 1998). However, no significant association was found between STR and SBP, suggesting that STR may not be a useful indicator of fat distribution in this age group. Similar results were reported in US adolescents (Stallones *et al.*, 1982).

The adverse impact of childhood and adolescent obesity on blood pressure and other CVD risk factors is well known (Srinivasan *et al.*, 1996; Freedman *et al.*, 1999a). The results of this study showed that obese adolescents had a significantly higher systolic and diastolic blood pressure than the non-obese, confirming previous observations that greater BMI in adolescence is associated with raised BP (Berkey *et al.*, 1998; Wilson *et al.*, 1985; Moussa *et al.*, 1994a). In addition to correlations and linear regression coefficients, odds ratio was used to examine the relationship between adolescents' obesity and blood pressure. The blood pressure status of the adolescents was defined according to the recommendations of the WHO Expert Committee of Hypertension Control (WHO, 1994), which were based on the sex and age specific guidelines of the Second Task Force of Blood Pressure Control in Children (Task Force on Blood Pressure Control in Children, 1987). Using standard sex and age-specific BMI cut-off points, it was found that obese adolescents had a substantially greater risk of having high blood pressure; obese boys and girls were 3.8 and 11 times more likely to have elevated blood pressure than the non-obese, respectively. These odd ratios were comparable to those reported by Freedman *et al.* (1999a) among 5 to 17-year-old children of the Bogalusa Heart Study (OR= 4.5, 95% CI=3.6-5.8). The risk of having elevated blood pressure also increased with increasing levels of percent body fat. These findings were in accordance with the results of earlier studies in which increased triceps skinfold (Gortmaker *et al.*, 1987) or excess percent body fat (Williams *et al.*, 1992) were used to examine the relationship between blood pressure and adiposity in children and adolescents.

Unless extremely elevated, blood pressure levels in children and adolescents do not appear to be related to disease outcomes. However, available data indicate a role for high blood pressure and obesity at this age in increasing risk of CVD in adulthood (Lauer & Clarke, 1989). Must *et al.* (1992) found that being overweight in adolescence was associated with an increased risk of morbidity from coronary heart disease and atherosclerosis in adulthood, independent of adult obesity. The effects of obesity in adolescence on adult morbidity and mortality may be related to the accumulation of intra-abdominal fat that occurs around the time of puberty. Studies on children and adolescents showed that increased central body fatness was significantly associated with a variety of metabolic and cardiovascular abnormalities that cluster with obesity, including elevated blood pressure, and lipoprotein profile disturbances (Gillum, 1999; Daniels *et al.*, 1999). Caprio *et al.* (1996) found that visceral fat, assessed using MRI, was significantly associated with basal insulin, triglycerides and HDL-cholesterol in obese adolescent girls. Although these studies and many others have linked regional fat distribution to CVD risk factors in children and adolescents, controversy still exists regarding the best anthropometric indicator of central obesity in this age group. Relaying on skinfold thickness to distinguish central from peripheral adiposity, Shear *et al.* (1987) showed that centrally located body fat (measured by subscapular skinfold) was strongly and directly related to SBP in children and young adults and that such a relationship was independent of peripheral fat (as measured by triceps skinfold). In a case control study on 6 to 17 year old school children from the United Arab Emirates, Moussa *et al.* (1994a) found that BMI, but not WHR, was associated with blood pressure and concluded that WHR may not be a reliable indicator of body fat patterning in this group of children. In contrast, Lurbe *et al.* (2001) found that excess accumulation of fat in the abdominal region in children and adolescents, quantified using WHR or WC, was positively related to the average of 24 hr SBP monitoring, independent of weight, height, sex and age. The use of WC rather than WHR for estimating central obesity has been emphasised in recent years. The WC can express abdominal fat accumulation better than the WHR does (Taylor *et al.*, 2000). This may be because in growing children the hip circumference may reflect changes in bones and muscles more than changes in fat. The present study's finding that WC in both boys and girls, and WHR in girls only, were significantly and positively associated with the risk of having high blood pressure, supports the concept that fat distribution is related to cardiovascular risks, of which elevated blood pressure is an important factor, in adolescents. The age-adjusted odds ratios showed that boys and girls in the uppermost tertile of WC were 6 and 7 times, respectively, more likely to have high blood pressure than those in the lowest tertiles of this measurement. These results, and the observation that among anthropometric indicators of body fat distribution, WC showed the strongest correlation with SBP, suggest that, as in adults (Pouliot *et al.*, 1994), WC may serve as a good index of central (abdominal) obesity in adolescents. This is particularly important in epidemiological studies, given the ease with which this measurement can be obtained.

The mechanism by which central fat deposition influences blood pressure in adolescents appears to be through changes in insulin sensitivity and its compensatory hyperinsulinemia. Increased insulin secretion has been shown to be present in adolescent obesity and to be related to the amount of intra-abdominal fat (Caprio & Tamborlane, 1999). Excessive insulin secretion leads to sodium and water retention and stimulation of sympathetic activity, which may in turn lead to hypertension.

The beneficial effects of physical exercise on blood pressure are well recognised (Halbert *et al.*, 1997). Despite the crude measure of physical activity behaviours used in this study, the adjusted odds ratios showed that adolescents who demonstrated an active lifestyle, such as frequent participation in sport outside school (OR=0.49, 95%CI=0.28, 0.86) or walking/cycling to school (OR=0.35, 95%CI=0.13, 0.91), had a significantly diminished risk of developing high blood pressure. These results are in accordance with the study of Kawabe *et al.* (2000) who showed that belonging to sports club was significantly associated with low diastolic blood pressure, decreased adiposity and healthier lipid profile in Japanese adolescent males. Wilson *et al.* (1985) reported that girls with elevated blood pressure were significantly less fit and had increased heart rate (at rest and during exercise) and obesity. The observed relationship between physical activity behaviour and blood pressure status in the present study appears to be confounded by BMI, since the significant associations were lost when the BMI was entered into the logistic regression model. However, a prior study in which this association was examined in a large cohort of college students in Scotland showed that insufficient outdoor exercise was significantly associated with higher BP levels, independent of BMI (Okasha *et al.*, 2000). It has been suggested that the effect of physical inactivity on cardiovascular risk factors may be mediated in part by an influence of physical inactivity on intra-abdominal fat (Hunter *et al.*, 1996). In adults, physical inactivity has been shown to be associated with excess visceral fatness (Bjorntorp, 1992). Despers *et al.* (1991) found that aerobic exercise resulted in a significant reduction of intra-abdominal adipose tissue, and plasma cholesterol and LDL-C levels in women. An intervention study on obese 7 to 11 year-old-girls showed that a 4-month aerobic training program resulted in a significant reduction of subcutaneous abdominal fat and that the increase in visceral abdominal fat was significantly less in the exercise group than in the control group which received no exercise, suggesting that physical training may have a slowing effect on the accumulation of visceral fat in obese children (Owens *et al.*, 1999).

One limitation of the study is that BP reading was recorded as the average of two measurements, which were taken after 5 minutes rest, but on one occasion only. Thus the possibility of errors that may have occurred in classifying adolescents as having high blood pressure, or normal blood pressure cannot be ruled out. However, the purpose of using blood pressure categories in the analysis was to obtain a general idea about the prevalence of elevated BP in the adolescent participants and its association with obesity, rather than to diagnose the presence of hypertension among them. In addition, treating BP as a dichotomous variable allowed the estimation of risk, using odds ratios, which are easier to interpret than regression coefficients.

The recognition of obesity (whether assessed by BMI, percent body fat, WC or WHR) in the present study as an important modifiable factor associated with risk of elevated blood pressure among Bahraini adolescents, may help target prevention towards high risk individuals in this age group. This is especially important in the light of evidence linking adolescent obesity with metabolic abnormalities and risk of cardiovascular diseases in adulthood.

6.4 PERCEPTION OF BODY WEIGHT STATUS

Perception of/and attitudes to body weight are important underlying psychological factors affecting BMI. Overemphasis on thinness can lead to unhealthy dieting practices and eating disorders, while underestimation of body weight may increase the risk of the development of overweight and obesity. Perception of body shape appears to be highly influenced by cultural and social factors. In Western countries, where thinness is considered by many to be the ideal or desirable objective, adolescent girls and young women feel great pressure to be thin (Wiseman *et al.*, 1992). However, the drive for thinness is not universal and preference for an overweight or even obese figure has been observed in some cultural groups and societies (WHO, 1989). Studies that have examined race/ethnic differences among US adolescent females have consistently shown that black girls were less likely to consider themselves as overweight and were more satisfied with their body size and shape than white girls (Desmond *et al.*, 1989; Kemper *et al.*, 1994; Story *et al.*, 1995). One possible explanation for the increased prevalence of obesity in Arab Gulf Countries may be cultural acceptance of overweight as the norm. A study from Kuwait showed that more than half of the women underestimated their weight, and about 40% reported weights which were in the overweight category as being appropriate for them (Al-Hamad, 1999).

The results of the present study revealed a significant discrepancy between adolescents' perceptions of body weight and their BMI-determined weight category. There was a tendency for teenagers to underestimate their weight status, which was especially noteworthy among the overweight and obese (Table 6.2). These findings are consistent with the study of Musaiger *et al.* (1994b) who found that 30% of female college students in the United Arab Emirates underestimated their weight, but were in disagreement with reports from Western countries, which showed that adolescents and young adults were more prone to report themselves to be overweight (Field *et al.*, 1999; Sciacca *et al.*, 1991; Pritchard *et al.*, 1997). Bahraini adolescents may not be aware of their obesity or may not know how much they should weigh. The traditional long, wide and comfortable clothes worn by men and women in Bahrain may prevent them from noticing the gradual gain of weight (Musaiger, 1987). Although no data are available, it can be said that more than three quarters of female school students adhere to the Islamic code for clothing in both their school uniform, which consists of a shirt and a long loose dress with a head cover, and in their habitual street attire or dress. Male school students have, on the other hand, the option to wear either the national dress (a long wide long robe) or a shirt and trousers.

Adolescents who are heavy but do not perceive themselves to be heavy are a cause of concern, because they may be less motivated to take steps to lose weight. Although obesity is a significant health problem in Bahrain and has been the focus of health education programs for a long time, school curricula do not contain information regarding what constitutes a healthy weight, nor do they address causes of obesity and its consequences (Musaiger, 1990).

Table 6.2. Summary of adolescents' perceptions of current weight by their actual BMI status

Actual weight status (BMI percentile)*	Adolescents' perception of current weight status		
	Underestimation %	Correct %	Overestimation %
Males			
Underweight	-	52.2	47.8
Normal weight	10.6	83.3	6.1
Overweight	60.0	40.0	-
Obese	80.6	19.4	-
Total	27.6	63.8	8.6
Females			
Underweight	-	62.5	37.5
Normal weight	13.0	74.8	12.2
Overweight	36.6	56.1	7.3
Obese	76.1	23.9	-
Total	29.6	60.6	9.7

* Based on the BMI for age percentile classification of the NHANES-1: underweight <5th, Normal weight ≥ 5th to < 85th, overweight ≥ 85th to < 95th, obesity ≥ 95th percentile (Must *et al*, 1991).

Adolescents' assessment of self body image may be related to other people's evaluation of their (adolescents') body size. Family members and friends are known to play an important role in communicating social norms to adolescents. The reaction and feedback regarding body size that adolescents receive from 'significant others' in their social surroundings, such as parents and peers, are likely to influence the adolescents' views about their weight. The results of the present study showed that 36% to 45% of the adolescents thought that their parents and peers would consider them to be leaner than they actually were. The percentage of adolescents who reported parental or peer underestimation was higher among those classified as overweight or obese than it was among those who were of normal weight. Thus it would appear that there is a greater acceptance of larger body size in Bahrain, and that for adolescents, being overweight may not be associated with social pressure or negative attitude as is the case in the West. This was further supported by the findings from the family environment study, in which adolescents' mothers were asked to rate their children's weight. More than one third of the obese adolescents' mothers classified their children as normal weight, and a similar proportion reported being satisfied with their obese children's weight. These results were in agreement with the study of Baughcum *et al.* (2000) on US preschool children, who found that nearly 80% of mothers failed to perceive their overweight children as overweight. Kertesz *et al.* (1992) reported that parents in Hungary feel that overweight children are more attractive than slim ones, and therefore children are encouraged to gain weight.

When silhouettes were used to obtain information about participants' current and ideal body image, a significant difference was observed in how adolescents' perceived their current and ideal body shapes. Boys of normal weight reported a preference for a heavier body shape, whereas normal weight girls indicated a desire to be thinner. It is possible that adolescent boys prefer a heavy body shape because they think it is more masculine or "macho" than a thinner one. Gender differences in ideal body image may reflect differences in how males and females value and perceive their bodies. It has been suggested that women perceive their body build as a function of weight and lower body parts, while men perceive theirs as a function of their upper body parts and muscularity (Tucker, 1985).

The results of the present study showed a widespread feeling of dissatisfaction with body weight, especially among girls. More than half the girls reported being dissatisfied with their body weight, compared to only one third of the boys. This is consistent with previous studies on US young adults (Sciacca *et al.*, 1991) and Spanish adolescents (Cuadrado *et al.*, 2000), which showed that females are more likely to feel discontent about their figures than males. It was of interest to note that among those classified as overweight or obese, about 15% reported having never thought about their weight in terms of satisfaction/dissatisfaction, and that some had even indicated a feeling of satisfaction with their body weight (21% of the boys and 6% of the girls). Body weight dissatisfaction may be a factor that stimulates weight loss activities. Thus the lack of concern observed among the heavy adolescents of this study may place them at an increased risk of obesity being continued into adulthood, as well as many obesity-associated morbidities.

A preference for the modern western thin body image was observed in the subgroup of normal weight adolescents. Among adolescents classified as normal weight, 12% of the girls reported themselves to be overweight or obese compared to only 6% of boys. Although these figures are much lower than those reported in the West (35-39% in girls and 6-11% in boys) (Desmond *et al.*, 1989; Pritchard *et al.*, 1997), they show that excessive concern over weight may also exist among Bahraini teenagers, especially females. Furthermore, despite having normal weight, over one third of these teenagers expressed dissatisfaction with their weight status and many reported previous attempts to lose weight. It is likely that the Western teenagers' preoccupation with the thin figure is passed on to adolescents in this country. Teenage girls who perceive themselves as overweight may be more prone to chronic dieting and eating disorders (French *et al.*, 1997). Whether the excessive concern over weight detected among the normal weight girls of this study is suggestive of the presence of eating disorders, the data do not lead to such conclusion.

In summary, this part of the research shows the existence of a distorted body image as reflected by the failure of many adolescents to correctly perceive overweight and obesity. Adolescents also showed evidence of being conscious about their figures as many were dissatisfied with their body weight and reported previous attempts to lose weight. Thus it seems reasonable to assume that among Bahraini adolescents, weight-related beliefs and attitudes which are at the two ends of the spectrum exist; a tolerance of obesity at one end and an exaggerated concern for its occurrence at the other. Understanding the way adolescents perceive their own body weight and how they feel about it could help to better understand factors contributing to the high rates of obesity seen in Bahrain. This is also important when designing intervention strategies, which are sensitive to population norms and more effective at promoting healthy body weight. Thus future studies on adolescents' obesity should take body image perception into consideration

CHAPTER VII: CONCLUSION AND RECOMMENDATIONS

7.1 CONCLUSION

Four important conclusions can be derived from this study:

Firstly, the prevalence of obesity among male and female 12 to 17 year-old-adolescents in Bahrain is 21% and 35%, respectively. Compared to previous surveys, the results of the present study show an increase in mean BMI values, indicating a secular trend of greater obesity that appears to have occurred in Bahraini adolescents during the 1986-2000 period. These findings have important public health implications, given the association we found between adolescent obesity and elevated blood pressure, and the recent evidence linking childhood and adolescent obesity to increased risk of obesity and morbidity in adulthood. Therefore programmes to prevent the development of obesity in children and adolescents are high priority.

Secondly, the results of the study confirmed previous reports about the relationship between socio-economic status and risk of obesity in Bahraini children and adults. There was a strong and direct relationship between the mother's level of education and adolescents' BMI status.

Thirdly, the present study identified several important and potentially modifiable factors associated with risk of obesity in Bahraini adolescents. Frequent snacking, distress eating and maternal physical inactivity were all independent factors associated with an increased risk of obesity. Factors associated with a reduced risk of obesity included playing sport outside school, walking or cycling to school and eating meals with the family. These factors constitute appropriate targets for interventions and should be taken into consideration when planning preventive strategies in order to reduce obesity levels and, the health implications of obesity in children and adolescents.

Fourthly, the study revealed a strong familial clustering of obesity in Bahrain. Thus obesity interventions should include selective preventive strategies targeting children and adolescents with one or both obese parents, since they are the population subgroups with a particularly high risk of obesity.

7.2 RECOMMENDATIONS

Obesity is a serious and widespread problem in the world. Statistics from developed and many developing countries suggest that the prevalence of childhood and adolescent obesity has increased substantially in the last few decades and it is likely that this trend will continue (WHO, 2000).

The demonstration that obesity in children and adolescents often tracks into adulthood and that it is associated with a variety of metabolic abnormalities that are critical to chronic disease development, make prevention of childhood and adolescent obesity an important public health goal. Furthermore, weight loss is difficult to achieve. Research on paediatric obesity treatment has documented small reductions in adiposity and a substantial relapse (Epstein *et al.*, 1998). Thus prevention remains the most effective method of controlling obesity, particularly if it started early in life. Intervention strategies should aim to modify eating behaviours and activity patterns so that unhealthy behaviours are replaced by new healthy behaviours that persist throughout childhood development and into adulthood, thereby contributing to lifelong maintenance of healthy weight.

Because of the multi-factorial nature of obesity and the uncertainty surrounding the effectiveness of many interventions/treatment approaches, strategies for preventing childhood obesity need to focus on key environmental risk factors. Recently, several lifestyle behaviours have been suggested as important targets for obesity prevention in children and adolescents. These are breastfeeding (von Kries *et al.*, 1999), reduction of TV viewing (Robinson, 1999) and an increase in physical activity (Kemper *et al.*, 1999). The family environment in relation to eating habits, specifically mother-child interactions may also offer a significant opportunity to affect food choice and eating behaviours, especially in small children (Birch & Davison, 2001).

The high prevalence of obesity documented in this study makes it clear that obesity is a serious problem among the adolescent population in Bahrain. Therefore the health authorities and concerned institutions should act immediately to establish population-based preventative strategies. To be most effective, these intervention programmes will have to incorporate a multidisciplinary approach that includes a comprehensive and integrated range of educational, environmental and economic strategies that must be developed with the full participation and commitment of health professionals, parents and different sectors of the community.

Finally, because adolescents are particularly vulnerable to the development of eating disorders, caution must be practised when designing and implementing obesity prevention programmes targeting this age group. This is because young people, especially girls, may misinterpret the message and acquire an exaggerated fear of fatness and consequently harmful eating practices that increase their risk of bulimia and anorexia nervosa. Thus the role of a healthy balanced diet in the regulation and maintenance of healthy weight must be emphasised

7.2.1 Specific Recommendations

7.2.1.1 Establish school-based obesity prevention programmes

Results of the study revealed a strong association between several dietary habits and physical activity behaviours, and the risk of obesity in adolescents. These factors constitute appropriate targets for intervention and can be best addressed within a school-based prevention programme. Schools provide an ideal setting in which obesity intervention can be delivered. This is because they allow easy access to the child and adolescent population as well as present opportunities for them to practice and reinforce healthy eating and physical activity behaviours (US Department of Health and Human Services, 1996). Therefore it is essential to establish a school-based obesity prevention program, which should aim to:

1. Improve and integrate the school nutrition curriculum:

At present there is no special nutrition course in schools. Knowledge about diet and nutrition is included in the curriculum of other subjects, such as science and home economics, and is often fragmented and of a general nature. There is a need, therefore, to review, expand and integrate the existing nutrition curriculum so that besides providing the conventional information, it should focus on issues specifically related to obesity, in order to help students adopt healthy eating habits and make sound nutritious choices. Examples include focusing on small behaviours such as reducing snacking and fast food intake, and encouraging eating meals with the family. Various learning strategies should be used, especially those that emphasize fun participatory activities and provide opportunities for students to practice healthy behaviours.

2. Improve the school physical education programme

The current school PE programme in Bahrain suffers from a major deficiency in both the quantity of weekly-allocated PE time, and the quality of the programme offered. Currently students in primary schools receive two 45-minute periods of PE per week, while those in the intermediate and secondary levels get only one 45-minute PE lesson per week. Thus the school PE should be improved in terms of frequency, quality and time spent in structured exercises. Sustained moderate to vigorous physical activity should be included in the PE curriculum at least 3 times per week. In addition, teachers should encourage children to increase their out-of-school physical activity, and reduce sedentary activities such as TV viewing and playing computer games. Teachers should also motivate students to build increased activity into their daily lives by encouraging walking or cycling to school, and performing household chores.

3. Provide in-service training for school teachers:

In-service training workshops should be carried out to provide all teachers involved in school-based interventions with the necessary knowledge and skills in the field of nutrition, obesity and physical education, as well as teaching methodology and behaviour-modification techniques.

4. Involve parents in school activities

Because parents strongly influence their children's eating environment and lifestyle behaviours, their cooperation and support is crucial. Thus school-based interventions should involve parents as much as possible in various activities in order to get their support and help. Examples include inviting parents to attend school-organised sports activities and nutrition seminars and giving students home assignments that they should do with their mothers, such as planning nutritious family meals.

5. Improve the quality of food and snacks sold in school canteens

Although large improvements have been made in school canteens, many schools still offer high fat or high sugar snacks such as crisps, pastries and fruit drinks. Thus policy regarding providing only nutritious food and snacks should be issued. This is important in order to improve the nutritional quality of foods consumed by students while at school, as well as to prevent sending mixed messages.

6. School clinic

School clinics offer an excellent opportunity for preventing and treating obesity. The school clinic should provide obesity intervention services such as screening, obesity management and counselling. Proper training should be provided for school nurses in assessment and management of overweight and obesity.

7.2.1.2 Provide sport and exercise facilities for children and adolescents

The results showed that out-of-school physical activity was an important and independent factor associated with a reduced risk of obesity in adolescents. Therefore, intervention efforts should include providing suitable places for children and adolescents to exercise and engage in physically active games such as sports clubs, play grounds and community recreational centres. This is particularly important for girls, as there is severe shortage of sports facilities for females.

7.2.1.3 Carry out health education campaigns targeting parents

The findings that the mother's lifestyle behaviours were important factors associated with a risk of obesity among adolescents, emphasise the role that parents can play (through modelling) in influencing their children's' behaviours. Thus intervention efforts should be focused at family level, particularly at mothers, to encourage them to adopt an active lifestyle. Health education through mass media can play a key role in this matter. An important message to parents is that in order for them to be able to increase their children's physical activity they should be active themselves.

7.2.1.4 Establish selective obesity prevention programmes directed at high risk groups

The present study showed that a family history of obesity is a strong and independent predictor of obesity in Bahraini adolescents. It is not clear whether such an association is due to genetic or family environmental influences. Nevertheless it seems reasonable to assume that both factors are involved in favouring the development of obesity in children. Therefore, intervention programmes should specifically target those children with one or both obese parents, since they are the subgroups with a particularly high risk of obesity. Furthermore, the custom of marriage between close relatives in the population of Bahrain and other Gulf States is very common and is believed to contribute to the high rates of hereditary anaemias in Bahrain (Musaiger, 1987). Hence appropriate health education in this matter may help to lower the prevalence of obesity as well as other genetic diseases.

7.2.2 General recommendations

7.2.2.1 Establish obesity prevention committee at national level

A high level committee consisting of government officials, health professionals, nutritionists, educators, and community and religious group leaders should be set up to launch a comprehensive obesity prevention programme targeting the child and adult population. Members of the committee should first carry out a situational analysis to assess the magnitude of the obesity problem, identify the most effective means to deal with it, and develop policy and preventative strategies. Subcommittees can then be formed to develop specific action plans and oversee implementation. Specific strategies should first be piloted to assess their feasibility and appropriateness. Regular evaluation (based on assessment of changes in predetermined indicators of dietary change, physical activity level and prevalence of overweight) should also be carried out to assess progress and improve plans.

7.2.2.2 Carry out a public health education campaign

Mass media efforts can positively facilitate behaviour change. Information on obesity, particularly childhood obesity, its definition, causes, health consequences and management, should be an integral part of health education messages conveyed through various types of media in Bahrain. Specific key points for media attention include promoting an active lifestyle for the whole family, reducing time spent in sedentary activities such as TV viewing, and to continue encouraging breastfeeding.

7.2.2.3 Establish specialised obesity clinics

There is a need to establish specialised health care services for the management of paediatric and adult obesity. Such obesity clinics can be established within the existing health care facilities in Bahrain (health centres, school clinics and hospitals) and should be able to provide primary care as well as secondary care (treatment). Guidelines that complement preventive strategies need to be developed for the assessment and management of obesity in children and adults.

7.2.2.4 Provide improved training for health professionals in obesity management and prevention

Efforts should be directed towards providing improved in-service training programmes for all health professionals involved in the management and prevention of obesity in Bahrain. In addition to providing the necessary knowledge and skills in these areas, the training should aim to change the negative attitudes that some health workers may have towards obesity and the obese, so that obesity can be viewed as a serious disease that can be treated through modifications of eating and exercise behaviours, and not as a personal trait or condition resulting from laziness or overindulgence.

7.2.2.5 Carry out further studies

1. BMI is a useful general indicator of obesity. However, like all other surrogate measures of fatness, it has several limitations. In addition of being affected by sex and age, the relationship between BMI and body fat is also influenced by

ethnicity (Daniels *et al.*, 1997; Prentice & Jebb, 2001). Furthermore the use of age and sex specific BMI cut-off points in children does not completely eliminate problems associated with its use, since the BMI-percent body fat relationship is also known to be affected by the stage of sexual maturation (Daniels *et al.*, 1997; Bini *et al.*, 2000). As a result, when BMI is used to classify obesity in individuals of different maturity levels or from different racial groups, it may provide misleading information.

Although the IOTF standard used in the present study improves on other BMI based- standards in being consistent with the adult obesity cut-off values, it lacks representation of many ethnic groups including the Arab population. Hence its use may underestimate or overestimate the true prevalence of obesity in the child and adolescent population of the Arab Gulf Region. A study that has evaluated the relationship between percent body fat and BMI in different ethnic groups showed that Asian races tend to have a lower BMI whereas American Blacks and Polynesians tend to have higher BMI for a given level of body fat than Caucasians (Deurenberg *et al.*, 1998). Such variation suggests that the currently used obesity BMI cut-off points may not be appropriate for non-Caucasian populations in whom the relationship between BMI and percent body fat may be different. The dependency of BMI on ethnicity may be due to differences in population's body build and relative leg length (sitting height) as well as differences in physical activity and energy intake (Deurenberg *et al.*, 1999).

The use of appropriate cut-off points for overweight and obesity is a matter of supreme importance in establishing reliable prevalence estimates for obesity and consequently prevention strategies. Therefore future studies should aim to define cut-off points which are specific for both the child and adult population of the Gulf Region and which are based on long-term health risks associated with elevated levels of BMI (such as mortality rate, hypertension, NIDDM and risk of persistence of obesity into adulthood). This may serve as an adequate classification system until an internationally accepted standard based on actual measurement of body fat becomes available.

2. Data on the habitual dietary intake of the child and adolescent population in Bahrain is scarce. Hence a study designed to investigate this issue is urgently needed.

3. There is a need for future studies to examine the relationship between the family environment (parents' eating habits and activity behaviours, and parenting style) and risk of obesity in schoolchildren.

4. In this study, an initial effort was taken to investigate the association between birthweight and breastfeeding and risk of obesity in adolescents. However, no significant association was observed. This could be due to the relatively small sample size, which may have limited the power of the study. Further investigation in this area may help to identify new methods for early preventive measures.

REFERENCES

ABAHUSSAIN, N.A., MUSAIGER, A.O., NICHOLLS, P.J. & STEVENS, R. (1999). Nutritional status of adolescent girls in the eastern province of Saudi Arabia. *Nutrition & Health* **13**. 171-177.

AHMED, M.L., ONG, K.K., MORRELL, D.J., COX, L., DRAYER, N., PERRY, L., PREECE, M.A. & DUNGER, D.B. (1999). Longitudinal study of leptin concentrations during puberty, sex differences and relationship to changes in body composition. *Journal of Clinical Endocrinology & Metabolism* **84**, 899-905.

AL-ABOUDI, F., SHARAF, E., SARHAN, N., & ZAMAN, E. (1995). Prevalence of obesity among children in primary government schools in Bahrain. (Unpublished). Arabian Gulf University, Bahrain.

AL-AMER, A. R. S. (1996). Barriers to practicing sports among women in Bahrain. MSc Thesis. Helwan University, Cairo, Egypt.

AL-HAMAD, N. (1999). Determinants and consequences of obesity in adult Kuwaiti females. PhD Thesis. London School of Hygiene & Tropical Medicine, London, UK.

AL-HAZZAA, H. & ALMUZAINI, K. (1999). Heart rate telemetry during physical education classes in Riyadh's intermediate schools (in Arabic). *King Saud University Journal* 11, 1-15.

ALLISON, D.B., FAITH, M.S. & NATHAN, J.S. (1996). Risch's lambda values for human obesity. *International Journal of Obesity & Related Metabolic Disorders* **20**, 990-999.

AL-MAHROOS, F. & MCKEIGUE, P. (1998). Obesity, physical activity and prevalence of diabetes in Bahraini Arab native population. *Bahrain Medical Bulletin* 20, 114-118.

AL-MANNAI, A., DICKERSON, J.W., MORGAN, J.B. & KHALFAN, H. (1996). Obesity in Bahraini adults. *Journal of the Royal Society of Health* **116**, 30-32.

AL-MOUSA, Z. & PARKASH, P. (2000). Prevalence of overweight and obesity among Kuwaiti children and adolescents. *Bahrain Medical Bulletin* 22, 123-127.

AL-NEYADI, A. (1995). Social and dietary factors associated with obesity in male university students in UAE. (Unpublished). Faculty of Medicine and Health Sciences, Al-Ain, UAE.

AL-NUAIM, A.R., AL-RUBEAAN, K., AL-MAZROU, Y., AL-ATTAS, O., AL-DAGHARI, N. & KHOJA, T. (1996a). High prevalence of overweight and obesity in Saudi Arabia. *International Journal of Obesity* **20**, 547-552.

AL-NUAIM, A.R., BAMIGBOYE, E.A. & AL-HERBISH, A. (1996b). The pattern of growth and obesity in Saudi Arabian male school children. *International Journal of Obesity & Related Metabolic Disorders* **20**, 1000-1005.

AMINE, E. K. (1980). Bahrain, Nutrition survey. Abu-Dhabi, UAE, UNICEF / Gulf Area Office.

ANDERSEN, R.E., CRESPO, C.J., BARTLETT, S.J., CHESKIN, L.J. & 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. *JAMA* **279**, 938-942.

ARAB WOMEN SPEAK OUT (2002). John Hopkins Center for Communication Programs. http://www.jhuccp.org/centerpubss/sp_8/chapter3.11/04/02

BANDINI, L.G., SCHOELLER, D.A. & CYR, H.N. (1990). Validity of reported energy intake in obese and non-obese adolescents. *American Journal of Clinical Nutrition* **52**, 421-425.

BAO, W., SRINIVASAN, S.R., WATTIGNEY, W.A. & BERENSON, G.S. (1995). The relation of parental cardiovascular disease to risk factors in children and young adults. The Bogalusa Heart Study. *Circulation* **91**, 365-371.

BARKER, D.J. (1997). Maternal nutrition, fetal nutrition, and disease in later life. *Nutrition* **13**, 807-813.

BARKER, D.J., HALES, C.N., FALL, C.H., OSMOND, C., PHIPPS, K. & CLARK, P.M. (1993). Type 2 (non-insulin-dependent) diabetes mellitus, hypertension and hyperlipidaemia (syndrome X): relation to reduced fetal growth. *Diabetologia* **36**, 62-67.

BARKER, M., ROBINSON, S., OSMOND, C. & BARKER, D.J. (1997). Birth weight and body fat distribution in adolescent girls. *Archives of Disease in Childhood* **77**, 381-383.

BAR-OR, O., FOREYT, J., BOUCHARD, C., BROWNELL, K.D., DIETZ, W.H., RAVUSSIN, E., SALBE, A.D., SCHWENGER, S., ST.JEOR, S. & TORUN, B. (1998). Physical activity, genetic, and nutritional considerations in childhood weight management. *Medicine & Science in Sports & Exercise* **30**, 2-10.

BAUGHCUM, A.E., CHAMBERLIN, L.A., DEEKS, C.M., POWERS, S.W. & WHITAKER, R.C. (2000). Maternal perceptions of overweight preschool children. *Pediatrics* **106**, 1380-1386.

BELLIZZI, M.C. & DIETZ, W.H. (1999). Workshop on childhood obesity: summary of the discussion. *American Journal of Clinical Nutrition* **70**, 173S-175S.

BELLIZZI, M. C., HORGAN, G. W., GUILLAUME, M., AND DIETZ, W. H. (2001). Prevalence of childhood and adolescent overweight and obesity in Asian and European Countries. In Obesity in Childhood and Adolescence, eds. Dietz, W. H. and Chen, C.. Pediatric Program (49). PP4-6. Nestlè Nutrition Workshop Series, Switzerland.

BERKEY, C.S., GARDNER, J. & COLDITZ, G.A. (1998). Blood pressure in adolescence and early adulthood related to obesity and birth size. *Obesity Research* **6**, 187-195.

BERKEY, C.S., ROCKETT, H.R., FIELD, A.E., GILLMAN, M.W., FRAZIER, A.L., CAMARGO, C.A., Jr. & COLDITZ, G.A. (2000). Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. *Pediatrics* **105**, E56

BEUNEN, G. & THOMIS, M. (1999). Genetic determinants of sports participation and daily physical activity. *International Journal of Obesity & Related Metabolic Disorders* **23 Suppl 3**, S55-S63

BINI, V., CELI, F., BERIOLI, M.G., BACOSI, M.L., STELLA, P., GIGLIO, P., TOSTI, L. & FALORNI, A. (2000). Body mass index in children and adolescents according to age and pubertal stage. *European Journal of Clinical Nutrition* **54**, 214-218.

BIRCH, L.L. & DAVISON, K.K. (2001). Family environmental factors influencing the developing behavioral controls of food intake and childhood overweight. *Pediatric Clinics of North America* **48**, 893-907.

BIRCH, L.L. & FISHER, J.O. (1998). Development of eating behaviors among children and adolescents. *Pediatrics* **101**, 539-549.

BIRCH, L.L. & FISHER, J.O. (2000). Mothers' child-feeding practices influence daughters' eating and weight. *American Journal of Clinical Nutrition* **71**, 1054-1061.

BJORNTORP, P. (1992). Abdominal fat distribution and disease: an overview of epidemiological data. *Annals of Medicine* **24**, 15-18.

BLAIR, D. AND GREGORY, W. B. (1985). The nutritional status of Bahraini girls aged 7-18 years. Bahrain Sport Institute, Bahrain (Unpublished report).

BLUNDELL, J.E., BURLEY, V.J., COTTON, J.R. & LAWTON, C.L. (1993). Dietary fat and the control of energy intake: evaluating the effects of fat on meal size and post-meal satiety. *American Journal of Clinical Nutrition* **57**, 772S-777S.

BLUNDELL, J.E. & KING, N.A. (1996). Overconsumption as a cause of weight gain: behavioural physiological interactions in the control of food intake (appetite). In *The origins and consequences of obesity*, pp.138-158. Wiley, Chichester: Ciba Foundation Symposium.

BODURTHA, J.N., MOSTELLER, M., HEWITT, J.K., NANCE, W.E., EAVES, L.J., MOSKOWITZ, W.B., KATZ, S. & SCHIEKEN, R.M. (1990). Genetic analysis of anthropometric measures in 11-year-old twins: the Medical College of Virginia Twin Study. *Pediatric Research* **28**, 1-4.

BOUCHARD, C., PÉRUSSE, L., RICE, T. & RAO, D.C. (1998). The genetics of obesity. In *Handbook of obesity*, eds. BRAY, G., BOUCHARD, C. & JAMES, W., pp. 157-190. New York: Dekker.

BOUCHARD, C., TREMBLAY, A., DESPRES, J.P., NADEAU, A., LUPIEN, P.J., THERIAULT, G., DUSSAULT, J., MOORJANI, S., PINAULT, S. & FOURNIER, G. (1990). The response to long-term overfeeding in identical twins. *New England Journal of Medicine* **322**, 1477-1482.

BOUCHARD, C., TREMBLAY, A., DESPRES, J.P., THERIAULT, G., NADEAU, A. & LUPIEN, P.J. (1994). The response to exercise with constant energy intake in identical twins. *Obesity Research* **2**, 400-410.

BRADDON, F.E., RODGERS, B., WADSWORTH, M.E. & DAVIES, J.M. (1986). Onset of obesity in a 36 year birth cohort study. *British Medical Journal Clinical Research Ed* . **293**, 299-303.

BRAMBILLA, P., MANZONI, P., SIRONI, S., DEL MASCHIO, A., DI NATALE, B. & CHIUMELLO, G. (1994). Peripheral and abdominal adiposity in childhood obesity. *International Journal of Obesity & Related Metabolic Disorders* **18**, 795-800.

BULL, N.L. (1988). Studies of the dietary habits, food consumption and nutrient intakes of adolescents and young adults. *World Review of Nutrition & Dietetics* **57**, 24-74.

BURKE, V., BEILIN, L.J. & UNBAR, D. (2001). Family lifestyle and parental body mass index as predictors of body mass index in Australian children: a longitudinal study. *International Journal of Obesity* **25**, 147-157.

CAPRIO, S., HYMAN, L.D., MCCARTHY, S., LANGE, R., BRONSON, M. & TAMBORLANE, W.V. (1996). Fat distribution and cardiovascular risk factors in obese adolescent girls: importance of the intra-abdominal fat depot. *American Journal of Clinical Nutrition* **64**, 12-17.

CAPRIO, S. & TAMBORLANE, W.V. (1999). Metabolic impact of obesity in childhood. *Endocrinology & Metabolism Clinics of North America* **28**, 731-747.

CDC (2000). Center of Disease Control growth charts: United States advanced data from vital and health statistics. (vo. 314), www.cdc.gov/growthcharts.. Hyattsville, MD, National Center for Health Statistics.

CENTRAL STATISTICS ORGANISATION. (2001). Basic Results: Population, Housing, Buildings & Establishments Census. Part one, Ministry of Cabinet Affairs, Kingdom of Bahrain

CHEHAB, F.F., MOUNZIH, K., LU, R. & LIM, M.E. (1997). Early onset of reproductive function in normal female mice treated with leptin. *Science* **275**, 88-90.

CHINN, S. & RONA, R.J. (2001). Prevalence and trends in overweight and obesity in three cross sectional studies of British Children, 1974-94. *BMJ* **322**, 24-26.

CHU, N.-F. (2001). Prevalence and trends of obesity among school children in Taiwan- the Taipei Children Heart Study. *International Journal of Obesity & Related Metabolic Disorders* **25**, 170-176.

CLEMENT, K., VAISSE, C., LAHLOU, N., CABROL, S., PELLOUX, V., CASSUTO, D., GOURMELEN, M., DINA, C., CHAMBAZ, J., LACORTE, J.M., BASDEVANT, A., BOUGNERES, P., LEBOUC, Y., FROGUEL, P. & GUY-GRAND, B. (1998). A mutation in the human leptin receptor gene causes obesity and pituitary dysfunction. *Nature* **392**, 398-401.

COLE, T.J., BELLIZZI, M.C. & FLEGAL, K.M. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* **320**, 1240-1243.

CONSIDINE, R.V., SINHA, M.K., HEIMAN, M.L., KRIAUCIUNAS, A., STEPHENS, T.W., NYCE, M.R., OHANNESIAN, J.P., MARCO, C.C., MCKEE, L.J. & BAUER, T.L. (1996). Serum immunoreactive-leptin concentrations in normal-weight and obese humans. *New England Journal of Medicine* **334**, 292-295.

CRAIG, S., GOLDBERG, J. & DIETZ, W.H. (1996). Psychosocial correlates of physical activity among fifth and eighth graders. *Preventive Medicine* **25**, 506-513.

CUADRADO, C., CARBAJAL, A. & MOREIRAS, O. (2000). Body perceptions and slimming attitudes reported by Spanish adolescents. *European Journal of Clinical Nutrition* **54 Suppl 1**, S65-S68

CULLEN, K.W., BARANOWSKI, T., RITTENBERRY, L., COSART, C., HEBERT, D. & DE MOOR, C. (2001). Child-reported family and peer influences on fruit, juice and vegetable consumption: reliability and validity of measures. *Health Education Research* **16**, 187-200.

CURHAN, G.C., WILLETT, W.C., RIMM, E.B., SPIEGELMAN, D., ASCHERIO, A.L. & STAMPFER, M.J. (1996). Birth weight and adult hypertension, diabetes mellitus, and obesity in US men. *Circulation* **94**, 3246-3250.

DABELEA, D., PETTITT, D.J., JONES, K.L. & ARSLANIAN, S.A. (1999). Type 2 diabetes mellitus in minority children and adolescents. An emerging problem. *Endocrinology & Metabolism Clinics of North America* **28**, 709-729.

DANIELS, S.R., KHOURY, P.R. & MORRISON, J.A. (1997). The utility of body mass index as a measure of body 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. & KIMBALL, T.R. (1999). Association of body fat distribution and cardiovascular risk factors in children and adolescents. *Circulation* **99**, 541-545.

DAVIES, P.S., GREGORY, J. & WHITE, A. (1995). Physical activity and body fatness in pre-school children. *International Journal of Obesity & Related Metabolic Disorders* **19**, 6-10.

DE ONIS, M. & BLOSSNER, M. (2000). Prevalence and trends of overweight among preschool children in developing countries. *American Journal of Clinical Nutrition* **72**, 1032-1039.

DEURENBERG, P., DEURENBERG YAP, M., WANG, J., LIN, F. P., & SCHMIDT, G. (1999). The impact of body build on the relationship between body mass index and percent body fat. *International Journal of Obesity* **23(5)**, 537-542.

DEURENBERG, P., YAP, M. & VAN STAVEREN, W. A. (1998). Body mass index and percent body fat: a meta analysis among different ethnic groups. *International Journal of Obesity* **22(12)**, 1164-1171.

DE VITO, E., LA TORRE, G., LANGIANO, E., BERARDI, D. & RICCIARDI, G. (1999). Overweight and obesity among secondary school children in Central Italy. *European Journal of Epidemiology* **15**, 649-654.

DEHEEGER, M., ROLLAND-CACHERA, M.F. & FONTVIEILLE, A.M. (1997). Physical activity and body composition in 10 year old French children: linkages with nutritional intake? *International Journal of Obesity & Related Metabolic Disorders* **21**, 372-379.

DESMOND, S.M., PRICE, J.H., HALLINAN, C. & SMITH, D. (1989). Black and white adolescents' perceptions of their weight. *Journal of School Health* **59**, 353-358.

DESPRES, J.P., POULIOT, M.C., MOORJANI, S., NADEAU, A., TREMBLAY, A., LUPIEN, P.J., THERIAULT, G. & BOUCHARD, C. (1991). Loss of abdominal fat and metabolic response to exercise training in obese women. *American Journal of Physiology* **261**, E159-E167

DIETZ, W.H. (1996). The role of lifestyle in health: the epidemiology and consequences of inactivity. *Proceedings of the Nutrition Society* **55**, 829-840.

DIETZ, W.H. (1997). Periods of risk in childhood for the development of adult obesity--what do we need to learn?. *Journal of Nutrition* **127**, 1884S-1886S.

DIETZ, W.H. (2000). Birth weight, socioeconomic class, and adult adiposity among African Americans. *American Journal of Clinical Nutrition* **72**, 335-336.

DIETZ, W.H. (2001). Breastfeeding may help prevent childhood overweight. *JAMA* **285**, 2506-2507.

DIETZ, W.H., BANDINI, L.G., MORELLI, J.A., PEERS, K.F. & CHING, P.L. (1994). Effect of sedentary activities on resting metabolic rate. *American Journal of Clinical Nutrition* **59**, 556-559.

DIETZ, W.H.J. & 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.J., GROSS, W.L. & KIRKPATRICK, J.A., Jr. (1982). Blount disease (tibia vara): another skeletal disorder associated with childhood obesity. *Journal of Pediatrics* **101**, 735-737.

DREWNOWSKI, A., KURTH, C.L. & RAHAIM, J.E. (1991). Taste preferences in human obesity: environmental and familial factors. *American Journal of Clinical Nutrition* **54**, 635-641.

DURANT, R.H., BARANOWSKI, T., JOHNSON, M. & THOMPSON, W.O. (1994). The relationship among television watching, physical activity, and body composition of young children. *Pediatrics* **94**, 449-455.

EGOLF, B., LASKER, J., WOLF, S. & POTVIN, L. (1992). The Roseto effect: a 50-year comparison of mortality rates. *American Journal of Public Health* **82**, 1089-1092.

ELLIOTT, K.G., KJOLHEDE, C.L., GOURNIS, E. & RASMUSSEN, K.M. (1997). Duration of breastfeeding associated with obesity during adolescence. *Obesity Research* **5**, 538-541.

ELLIS, K.J. (1996). Measuring body fatness in children and young adults: comparison of bioelectric impedance analysis, total body electrical conductivity, and dual-energy X-ray absorptiometry. *International Journal of Obesity & Related Metabolic Disorders* **20**, 866-873.

EPSTEIN, L.H., MYERS, M.D., RAYNOR, H.A. & SAELENS, B.E. (1998). Treatment of pediatric obesity. *Pediatrics* **101**, 554-570.

EPSTEIN, L.H., PALUCH, R.A., GORDY, C.C. & DORN, J. (2000). Decreasing sedentary behaviors in treating pediatric obesity. *Archives of Pediatrics & Adolescent Medicine* **154**, 220-226.

FAO (2000). Food balance sheet. Food and Agriculture Organisation, Rome, Italy.

FEUNEKES, G.I., DE GRAAF, C., MEYBOOM, S. & VAN STAVEREN, W.A. (1998). Food choice and fat intake of adolescents and adults: associations of intakes within social networks. *Preventive Medicine* **27**, 645-656.

FIDANZA, F. (1991). Anthropometric methodology. In *Nutritional Assessment: a Manual for Population Studies*, ed. FIDANZA, F., pp. 1-43. London: Chapman & Hall.

FIELD, A.E., CAMARGO, C.A.J., TAYLOR, C.B., BERKEY, C.S., FRAZIER, A.L., GILLMAN, M.W. & COLDITZ, G.A. (1999). Overweight, weight concerns, and bulimic behaviors among girls and boys. *Journal of the American Academy of Child & Adolescent Psychiatry* **38**, 754-760.

FIELD, A.E., WOLF, A.M., HERZOG, D.B., CHEUNG, L. & COLDITZ, G.A. (1993). The relationship of caloric intake to frequency of dieting among preadolescent and adolescent girls. *Journal of the American Academy of Child & Adolescent Psychiatry* **32**, 1246-1252.

FIGUEROA-COLON, R., FRANKLIN, F.A., LEE, J.Y., ALDRIDGE, R. & ALEXANDER, L. (1997). Prevalence of obesity with increased blood pressure in elementary school-aged children. *Southern Medical Journal* **90**, 806-813.

FISHER, J.O. & BIRCH, L.L. (1995). Fat preferences and fat consumption of 3- to 5-year-old children are related to parental adiposity. *Journal of the American Dietetic Association* **95**, 759-764.

FISHER, J.O. & BIRCH, L.L. (1999). Restricting access to palatable foods affects children's behavioral response, food selection, and intake. *American Journal of Clinical Nutrition* **69**, 1264-1272.

FLEGAL, K.M., OGDEN, C.L., WEI, R., KUCZMARSKI, R.L. & JOHNSON, C.L. (2001). Prevalence of overweight in US children: comparison of US growth charts from the Centers for Disease Control and Prevention with other reference values for body mass index. *American Journal of Clinical Nutrition* **73**, 1086-1093.

FOGELHOLM, M., NUUTINEN, O., PASANEN, M. & MYOHANEN, E. (1999). Parent-child relationship of physical activity patterns and obesity. *International Journal of Obesity & Related Metabolic Disorders* **23**, 1262-1268.

FORBES, G.B. (1977). Nutrition and growth. *Journal of Pediatrics* **91**, 40-42.

FOX, K., PETERS, D., ARMSTRONG, N., SHARPE, P. & BELL, M. (1993). Abdominal fat deposition in 11-year-old children. *International Journal of Obesity & Related Metabolic Disorders* **17**, 11-16.

FREEDMAN, D.S., DIETZ, W.H., SRINIVASAN, S.R. & BERENSON, G.S. (1999a). The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics* **103**, 1175-1182.

FREEDMAN, D.S., SERDULA, M.K., SRINIVASAN, S.R. & BERENSON, G.S. (1999b). Relation of circumferences and skinfold thicknesses to lipid and insulin concentrations in children and adolescents: the Bogalusa Heart Study. *American Journal of Clinical Nutrition* **69**, 308-317.

FRENCH, S.A., HARNACK, L. & JEFFERY, R.W. (2000). Fast food restaurant use among women in the Pound of Prevention study: dietary, behavioral and demographic correlates. *International Journal of Obesity & Related Metabolic Disorders* **24**, 1353-1359.

FRENCH, S.A., STORY, M., NEUMARK-SZTAINER, D., DOWNES, B., RESNICK, M. & BLUM, R. (1997). Ethnic differences in psychosocial and health behavior correlates of dieting, purging, and binge eating in a population-based sample of adolescent females. *International Journal of Eating Disorders* **22**, 315-322.

FRENCH, S.A., STORY, M., NEUMARK-SZTAINER, D., FULKERSON, J.A. & HANNAN, P. (2001). Fast food restaurant use among adolescents: associations with nutrient intake, food choices and behavioral and psychosocial variables. *International Journal of Obesity* **25** , 1823-1833.

FRENCH, S.A., STORY, M. & PERRY, C.L. (1995). Self-esteem and obesity in children and adolescents: a literature review. *Obesity Research* **3**, 479-490.

FRISANCHO, A.R. (1981). New norms of upper limb fat and muscle areas for assessment of nutritional status. *American Journal of Clinical Nutrition* **34**, 2540-2545.

FRISANCHO, A.R. (2000). Prenatal compared with parental origins of adolescent fatness. *American Journal of Clinical Nutrition* **72**, 1186-1190.

FRISCH, R.E. & MCARTHUR, J.W. (1974). Menstrual cycles: fatness as a determinant of minimum weight for height necessary for their maintenance or onset. *Science* **185**, 949-951.

GARAULET, M., MARTINEZ, A., VICTORIA, F., PEREZ-LLAMAS, F., ORTEGA, R.M. & ZAMORA, S. (2000). Difference in dietary intake and activity level between normal-weight and overweight or obese adolescents. *Journal of Pediatric Gastroenterology & Nutrition* **30**. 253-258.

GASSER, T., ZIEGLER, P., KNEIP, A., PRADER, A., MOLINARI, L. & LARGO, R.H. (1993). The dynamics of growth of weight, circumferences and skinfolds in distance, velocity and acceleration. *Annals of Human Biology* **20**, 239-259.

GAZZANIGA, J.M. & BURNS, T.L. (1993). Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. *American Journal of Clinical Nutrition* **58**, 21-28.

GILLMAN, M.W., S.L., CAMARGO, C.A.J., BERKEY, C.S., FRAZIER, A.L., ROCKETT, H.R., FIELD, A.E. & COLDITZ, G.A. (2001). Risk of overweight among adolescents who were breastfed as infants. *JAMA* **285**, 2461-2467.

GILLMAN, M.W., S.L., FRAZIER, A.L., ROCKETT, H.R., CAMARGO, C.A., Jr., FIELD, A.E., BERKEY, C.S. & COLDITZ, G.A. (2000). Family dinner and diet quality among older children and adolescents. *Archives of Family Medicine* **9**, 235-240.

GILLUM, R.F. (1999). Distribution of waist-to-hip ratio, other indices of body fat distribution and obesity and associations with HDL cholesterol in children and young adults aged 4-19 years: The Third National Health and Nutrition Examination Survey. *International Journal of Obesity & Related Metabolic Disorders* **23**, 556-563.

GILLUM, R.F., MUSSOLINO, M.E. & MADANS, J.H. (1998). Body fat distribution and hypertension incidence in women and men. The NHANES I Epidemiologic Follow-up Study. *International Journal of Obesity & Related Metabolic Disorders* **22**, 127-134.

GOLAN, M. & WEIZMAN, A. (1998). Reliability and validity of the Family Eating and Activity Habits Questionnaire. *European Journal of Clinical Nutrition* **52**, 771-777.

GORAN, M.I., DRISCOLL, P., JOHNSON, R. & HUNTER, G. (1996). Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. *American Journal of Clinical Nutrition* **63**, 299-305.

GORAN, M.I. & GOWER, B.A. (1999). Relation between visceral fat and disease risk in children and adolescents. *American Journal of Clinical Nutrition* **70**, 149S-156S.

GORAN, M.I., REYNOLDS, K.D. & LINDQUIST, C.H. (1999). Role of physical activity in the prevention of obesity in children. *International Journal of Obesity & Related Metabolic Disorders* **23 Suppl 3**, S18-S33

GORDON-LARSEN, P., MCMURRAY, R.G. & POPKIN, B.M. (1999). Adolescent physical activity and inactivity vary by ethnicity: The National Longitudinal Study of Adolescent Health. *Journal of Pediatrics* **135**, 301-306.

GORDON-LARSEN, P., MCMURRAY, R.G. & POPKIN, B.M. (2000). Determinants of adolescent physical activity and inactivity patterns. *Pediatrics* **105**, E83

GORTMAKER, S.L., DIETZ, W.H., SOBOL, A.M. & WEHLER, C.A. (1987). Increasing pediatric obesity in the United States. *American Journal of Diseases of Children* **141**, 535-540.

GORTMAKER, S.L., MUST, A., PERRIN, J.M. & DIETZ, W.H. (1993). Social and economic consequences of overweight in adolescence and young adulthood. *New England Journal of Medicine* **329**, 1008-1012.

GORTMAKER, S.L., MUST, A., SOBOL, A.M., PETERSON, K., COLDITZ, G.A. & DIETZ, W.H. (1996). Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Archives of Pediatrics & Adolescent Medicine* **150**, 356-362.

GUANSHENG, M. A. (2001). Environmental factors leading to pediatric obesity in the developing world. In Obesity in Childhood and Adolescence. DIETZ, W. H. AND CHEN, C. eds. Pediatric Program (49), pp 34-37. Nestlè Nutrition Workshop Series, Switzerland.

GUILLAUME, M. (1999). Defining obesity in childhood: current practice. *American Journal of Clinical Nutrition* **70**, 126S-130S.

GUILLAUME, M. & BJORNTORP, P. (1996). Obesity in children. Environmental and genetic aspects. *Hormone & Metabolic Research* **28**, 573-581.

GUILLAUME, M., LAPIDUS, L., BECKERS, F., LAMBERT, A. & BJORNTORP, P. (1995). Familial trends of obesity through three generations: the Belgian-Luxembourg child study. *International Journal of Obesity & Related Metabolic Disorders* **19 Suppl 3**, S5-S9

GUILLAUME, M., LAPIDUS, L. & LAMBERT, A. (1998). Obesity and nutrition in children. The Belgian Luxembourg Child Study IV. *European Journal of Clinical Nutrition* **52**, 323-328.

GUO, S.S., ROCHE, A.F., CHUMLEA, W.C., GARDNER, J.D. & 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.

HALBERT, J.A., SILAGY, C.A., FINUCANE, P., WITHERS, R.T., HAMDORF, P.A. & ANDREWS, G.R. (1997). The effectiveness of exercise training in lowering blood pressure: a meta-analysis of randomized controlled trials of 4 weeks or longer. *Journal of Human Hypertension* **11**, 641-649.

HALL, J.E. (1997). Mechanisms of abnormal renal sodium handling in obesity hypertension. *American Journal of Hypertension* **10**, 49S-55S.

HANLEY, A.J., HARRIS, S.B., GITTELSOHN, J., WOLEVER, T.M., SAKSVIG, B. & ZINMAN, B. (2000). Overweight among children and adolescents in a Native Canadian community: prevalence and associated factors. *American Journal of Clinical Nutrition* **71**, 693-700.

HEDIGER, M.L., OVERPECK, M.D., KUCZMARSKI, R.J. & RUAN, W.J. (2001). Association between infant breastfeeding and overweight in young children. *JAMA* **285**, 2453-2460.

HERNANDEZ, B., GORTMAKER, S.L., COLDITZ, G.A., PETERSON, K.E., LAIRD, N.M. & 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 & Related Metabolic Disorders* **23**, 845-854.

HILL, A.J., DRAPER, E. & STACK, J. (1994). A weight on children's minds: body shape dissatisfactions at 9-years old. *International Journal of Obesity & Related Metabolic Disorders* **18**, 383-389.

HILL, J.O. & PETERS, J.C. (1998). Environmental contributions to the obesity epidemic. *Science* **280**, 1371-1374.

HIMES, J.H. (1989). Reliability of anthropometric methods and replicate measurements. *American Journal of Physical Anthropology* **79**, 77-80.

HIMES, J.H. & DIETZ, W.H. (1994). Guidelines for overweight in adolescent preventive services: recommendations from an expert committee. The Expert Committee on Clinical Guidelines for Overweight in Adolescent Preventive Services. *American Journal of Clinical Nutrition* **59**, 307-316.

HIMES, J.H., ROCHE, A.F. & WEBB, P. (1980). Fat areas as estimates of total body fat. *American Journal of Clinical Nutrition* **33**, 2093-2100.

HOPPIN, A.G. & KAPLAN, L.M. (1999). The leptin era: new insight into the mechanisms of body weight homeostasis. *Journal of Pediatric Gastroenterology & Nutrition* **29**, 250-264.

HORSWILL, C.A. & ZIPF, W.B. (1991). Elevated blood pressure in obese children: influence of gender, age, weight and serum insulin levels. *International Journal of Obesity* **15**, 453-459.

HUNTER, G.R., KEKES-SZABO, T., TREUTH, M.S., WILLIAMS, M.J., GORAN, M. & PICHON, C. (1996). Intra-abdominal adipose tissue, physical activity and cardiovascular risk in pre- and post-menopausal women. *International Journal of Obesity & Related Metabolic Disorders* **20**, 860-865.

JAHNS, L., A.M. & POPKIN, B.M. (2001). The increasing prevalence of snacking among US children from 1977 to 1996. *Journal of Pediatrics* **138**, 493-498.

JANZ, K.F., NIELSEN, D.H., CASSADY, S.L., COOK, J.S. & WU, Y.T. (1993). Cross-validation of the Slaughter skinfold equations for children and adolescents. *Medicine & Science in Sports & Exercise* **25**, 1070-1076.

JEFFERY, R.W. & FRENCH, S.A. (1996). Socioeconomic status and weight control practices among 20- to 45-year-old women. *American Journal of Public Health* **86**, 1005-1010.

JOHNSON, S.L. & BIRCH, L.L. (1994). Parents' and children's adiposity and eating style. *Pediatrics* **94**, 653-661.

KANDA, A., WATANABE, Y. & KAWAGUCHI, T. (1997). Estimation of obesity in schoolchildren by measuring skinfold thickness. *Public Health* **111**, 29-32.

KAWABE, H., MURATA, K., SHIBATA, H., HIROSE, H., TSUJIOKA, M., SAITO, I. & SARUTA, T. (2000). Participation in school sports clubs and related effects on cardiovascular risk factors in young males. *Hypertension Research* **23**, 227-232.

KEMPER, H.C., POST, G.B., TWISK, J.W. & VAN MECHELEN, W. (1999). Lifestyle and obesity in adolescence and young adulthood: results from the Amsterdam Growth And Health Longitudinal Study (AGAHLS). *International Journal of Obesity & Related Metabolic Disorders* **23 Suppl 3**, S34-S40

KEMPER, K.A., SARGENT, R.G., WANZER-DRANE, J., VALOIS, R.F. & HUSSEY, J.R. (1994). Black and white females' perceptions of ideal body size and social norms. *Obesity Research* **2**, 117-126.

KERTESZ, M., POLLAK, Z. & GREINER, E. (1992). Evaluation of self-image of overweight teenagers living in Budapest. *Journal of Adolescent Health* **13**, 396-397.

KHAN, M.A. (1981). Evaluation of food selection patterns and preferences. *Critical Reviews in Food Science & Nutrition* **15**, 129-153.

KING, G.A., FITZHUGH, E.C., BASSETT, D.R.J., MCLAUGHLIN, J.E., STRATH, S.J., SWARTZ, A.M. & THOMPSON, D.L. (2001). Relationship of leisure-time physical activity and occupational activity to the prevalence of obesity. *International Journal of Obesity* **25**, 606-612.

KIRKWOOD, B.R. (1988). Calculation of required sample size. In *Essentials of Medical Statistics*, pp. 191-200. London: Blackwell Scientific Publications.

KLESGES, R.C., HADDOCK, C.K., STEIN, R.J., KLESGES, L.M., ECK, L.H. & HANSON, C.L. (1992). Relationship between psychosocial functioning and body fat in preschool children: a longitudinal investigation. *Journal of Consulting & Clinical Psychology* **60**, 793-796.

KLESGES, R.C., MALOTT, J.M., BOSCHEE, P.F. & WEBER, J.M. (1986). The effects of parental influences on children's food intake, physical activity, and relative weight. *International Journal of Eating Disorders* **5**, 335-346.

KLESGES, R.C., SHELTON, M.L. & KLESGES, L.M. (1993). Effects of television on metabolic rate: potential implications for childhood obesity. *Pediatrics* **91**, 281-286.

KOHL, H.W. & HOBBS, K.E. (1998). Development of physical activity behaviors among children and adolescents. *Pediatrics* **101**, 549-554.

KOTANI, K., NISHIDA, M., YAMASHITA, S., FUNAHASHI, T., TOKUNAGA, K., ISHIKAWA, K., TARUI, S. & MATSUZAWA, Y. (1997). Two decades of annual medical examinations in Japanese obese children: do obese children grow into obese adults? *International Journal of Obesity & Related Metabolic Disorders* **21**, 912-921.

KROMHOUT, D., SARIS, W.H. & HORST, C.H. (1988). Energy intake, energy expenditure, and smoking in relation to body fatness: the Zutphen Study. *American Journal of Clinical Nutrition* **47**, 668-674.

LAU, R.R., QUADREL, M.J. & HARTMAN, K.A. (1990). Development and change of young adults' preventive health beliefs and behavior: influence from parents and peers. *Journal of Health & Social Behavior* **31**, 240-259.

LAUER, R.M. & CLARKE, W.R. (1989). Childhood risk factors for high adult blood pressure: the Muscatine Study. *Pediatrics* **84**, 633-641.

LECCIA, G., MAROTTA, T., MASELLA, M.R., MOTTOLA, G., MITRANO, G., GOLIA, F., CAPITANATA, P., GUIDA, L., CONTALDO, F. & FERRARA, L.A. (1999). Sex-related influence of body size and sexual maturation on blood pressure in adolescents. *European Journal of Clinical Nutrition* **53**, 333-337.

LEE, Y., MITCHELL, D.C., SMICIKLAS-WRIGHT, H. & BIRCH, L.L. (2001). Diet quality, nutrient intake, weight status, and feeding environments of girls meeting or exceeding recommendations for total dietary fat of the American Academy of Pediatrics. *Pediatrics* **107**, E95

LEIBEL, R.L., ROSENBAUM, M. & HIRSCH, J. (1995). Changes in energy expenditure resulting from altered body weight. *New England Journal of Medicine* **332**, 621-628.

LEMIEUX, S., PRUD'HOMME, D., BOUCHARD, C. & TREMBLAY, A. (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.

LIESE, A.D., HIRSCH, T., VON MUTIUS, E., KEIL, U., LEUPOLD, W. & WEILAND, S.K. (2001). Inverse association of overweight and breast feeding in 9 to 10-y-old children in Germany. *International Journal of Obesity* **25**, 1644-1650.

LIONIS, C., KAFATOS, A., VLACHONIKOLIS, J., VAKAKI, M., TZORTZI, M. & PETRAKI, A. (1991). The effects of a health education intervention program among Cretan adolescents. *Preventive Medicine* **20**, 685-699.

LISSAU, I. & SORENSEN, T.I. (1994). Parental neglect during childhood and increased risk of obesity in young adulthood. *Lancet* **343**, 324-327.

LISSNER, L. & HEITMANN, B.L. (1995). Dietary fat and obesity: evidence from epidemiology. *European Journal of Clinical Nutrition* **49**, 79-90.

LOHMAN, T.G. (1992). Prediction equations and skinfolds, bioelectric impedance and body mass index. In *Advances in body composition assessment. Current issues in exercise science series*, Champaign, IL: Human Kinetics Publishers.

LUCAS, A., SARSON, D.L., BLACKBURN, A.M., ADRIAN, T.E., AYNSLEY-GREEN, A. & BLOOM, S.R. (1980). Breast vs bottle: endocrine responses are different with formula feeding. *Lancet* **1**, 1267-1269.

LUEPKER, R.V., PERRY, C.L., MCKINLAY, S.M., NADER, P.R., PARCEL, G.S., STONE, E.J., WEBBER, L.S., ELDER, J.P., FELDMAN, H.A. & JOHNSON, C.C. (1996). Outcomes of a field trial to improve children's dietary patterns and physical activity. The Child and Adolescent Trial for Cardiovascular Health. CATCH collaborative group. *JAMA* **275**, 768-776.

LURBE, E., ALVAREZ, V. & REDON, J. (2001). Obesity, body fat distribution, and ambulatory blood pressure in children and adolescents. *Journal of Clinical Hypertension* **3**, 362-367.

MACLURE, K.M., HAYES, K.C., COLDITZ, G.A., STAMPFER, M.J. & WILLETT, W.C. (1989). Weight, diet, and the risk of symptomatic gallstones in middle-aged women. *New England Journal of Medicine* **321**, 563-569.

MAFFEIS, C., MICCIOLO, R., MUST, A., ZAFFANELLO, M. & PINELLI, L. (1994). Parental and perinatal factors associated with childhood obesity in north-east Italy. *International Journal of Obesity & Related Metabolic Disorders.* **18**, 301-305.

MAFFEIS, C., PIETROBELLI, A., GREZZANI, A., PROVERA, S. & TATO, L. (2001). Waist circumference and cardiovascular risk factors in pre-pubertal children. *Obesity Research* **9**, 179-187.

MAFFEIS, C., TALAMINI, G. & TATO, L. (1998). Influence of diet, physical activity and parents' obesity on children's adiposity: a four-year longitudinal study. *International Journal of Obesity & Related Metabolic Disorders* **22**, 758-764.

MALINA, R.M. & KATZMARZYK, P.T. (1999). Validity of the body mass index as an indicator of the risk and presence of overweight in adolescents. *American Journal of Clinical Nutrition* **70**, 131S-136S.

MALLORY, G.B.J., FISER, D.H. & JACKSON, R. (1989). Sleep-associated breathing disorders in morbidly obese children and adolescents. *Journal of Pediatrics* **115**, 892-897.

MARCUS, C.L., CURTIS, S., KOERNER, C.B., JOFFE, A., SERWINT, J.R. & LOUGHLIN, G.M (1996). Evaluation of pulmonary function and polysomnography in obese children and adolescents. *Pediatric Pulmonology* **21**, 176-183.

MARSHALL, J.D., HAZLETT, C.B., SPADY, D.W., CONGER, P.R. & QUINNEY, H.A. (1991). Validity of convenient indicators of obesity. *Human Biology* **63**, 137-153.

MARTINEZ, E., DEVESA, M., BACALLAO, J. & AMADOR, M. (1994). Percentiles of the waist-hip ratio in Cuban scholars aged 4.5 to 20.5 years. *International Journal of Obesity & Related Metabolic Disorders* **18**, 557-560.

MARTORELL, R., STEIN, A.D. & SCHROEDER, D.G. (2001). Early nutrition and later adiposity. *Journal of Nutrition* **131**, 874S-880S.

MCGLOIN, A.F., LIVINGSTONE, M.B., GREENE, L.C., WEBB, S.E., GIBSON, J.M., JEBB, S.A., COLE, T.J., COWARD, W.A., WRIGHT, A. & PRENTICE, A.M. (2002). Energy and fat intake in obese and lean children at varying risk of obesity. *International Journal of Obesity* **26**, 200-207.

MCMURRAY, R.G., HARRELL, J.S., DENG, S., BRADLEY, C.B., COX, L.M. & BANGDIWALA, S.I. (2000). The influence of physical activity, socioeconomic status, and ethnicity on the weight status of adolescents. *Obesity Research* **8**, 130-139.

MINISTRY OF HEALTH (2000). Medical statistics report. Bahrain, Ministry of Health.

MOKHTAR, N., ELATI, J., CHABIR, R., BOUR, A., ELKARI, K., SCHLOSSMAN, N.P., CABALLERO, B. & AGUENAOU, H. (2001). Diet culture and obesity in northern Africa. *Journal of Nutrition* **131**, 887S-892S.

MONTAGUE, C.T., FAROOQI, I.S., WHITEHEAD, J.P., SOOS, M.A., RAU, H., WAREHAM, N.J., SEWTER, C.P., DIGBY, J.E., MOHAMMED, S.N., HURST, J.A., CHEETHAM, C.H., EARLEY, A.R., BARNETT, A.H., PRINS, J.B. & O'RAHILLY, S. (1997). Congenital leptin deficiency is associated with severe early-onset obesity in humans. *Nature* **387**, 903-908.

MOORE, L.L., LOMBARDI, D.A., WHITE, M.J., CAMPBELL, J.L. & ELLISON, R.C. (1991). Influence of parents' physical activity levels on activity levels of young children. *Journal of Pediatrics* **118**, 215-219.

MOSSBERG, H.O. (1989). 40-year follow-up of overweight children. *Lancet* **2**, 491-493.

MO-SUWAN, L., JUNJANA, C. & PUETPAIBOON, A. (1993). Increasing obesity in school children in a transitional society and the effect of the weight control program *Southeast Asian Journal of Tropical Medicine & Public Health* **24**, 590-594.

MOUSSA, M.A., SKAIK, M.B., SELWANES, S.B., YAGHY, O.Y. & S.A. (1994a). Contribution of body fat and fat pattern to blood pressure level in school children. *European Journal of Clinical Nutrition* **48**, 587-590.

MOUSSA, M.A., SKAIK, M.B., SELWANES, S.B., YAGHY, O.Y. & S.A. (1994b). Factors associated with obesity in school children. *International Journal of Obesity & Related Metabolic Disorders* **18**, 513-515.

MUSAIGER, A. O. (1982). Factors influencing food consumption in Bahrain. *Ecology of Food and Nutrition* **12**, 39-48.

MUSAIGER, A.O. (1987). The state of food and nutrition in the Arabian Gulf Countries. *World Review of Nutrition & Dietetics* 54, 105-173.

MUSAIGER, A. O. (1990). Child Nutrition in the Arab Gulf. Society for the Development of Arab childhood, Kuwait (in Arabic), Kuwait.

MUSAIGER, A. O. (1991). Nutritional and health status of Omani families. UNICEF/ Muscat office, Oman.

MUSAIGER, A.O. (1993). Socio-cultural and economic factors affecting food consumption patterns in the Arab countries. *Journal of the Royal Society of Health* **113**, 68-74.

MUSAIGER, A.O. (1994a). Nutritional status and dietary habits of adolescent girls in Oman *Ecology of Food and Nutrition* 31, 227-237.

MUSAIGER, A.O. (1994b). Knowledge and attitudes of university female students toward obesity. *Int'l .Quarterly of Community Health Education* 14, 337-343.

MUSAIGER, A. O. (2000a). Food habits of secondary school students in UAE. (unpublished). Bahrain Center for Studies and Research, Bahrain.

MUSAIGER, A.O. (2000b). The state of nutrition in Bahrain. *Nutrition & Health* **14**, 63-74

MUSAIGER, A.O. & AL-ANSARI, M. (1992). Factors associated with obesity among women in Bahrain. *Int'l. Quarterly of Community Health Education* **12**, 129-136.

MUSAIGER, A.O., AL-ANSARI, M. & AL-MANNAI, M. (2000a). Anthropometry of adolescent girls in Bahrain, including body fat distribution. *Annals of Human Biology* **27**, 507-515.

MUSAIGER, A.O., AL-AWADI, A. & AL-MANNAI, M. (2000b). Life style and social factors associated with obesity among the Bahraini adult population. *Ecology of Food and Nutrition* 39, 121-133.

MUSAIGER, A.O. & AL-MANNAI, M. (2000). Factors related to weight status of the adult Bahraini population: a community based study. *Bahrain Medical Bulletin* **22**, 119-122.

MUSAIGER, A.O. & AL-ROOMI, K.A. (1997). Prevalence of risk factors for cardiovascular diseases among men and women in an Arab Gulf community. *Nutrition & Health* **11**, 149-157.

MUSAIGER, A.O. & GREGORY, W.B. (2000). Profile of body composition of school children (6-18y) in Bahrain. *International Journal of Obesity & Related Metabolic Disorders* **24**, 1093-1096.

MUSAIGER, A.O., GREGORY, W.B. & HAAS, J.D. (1989). Growth patterns of school-children in Bahrain. *Annals of Human Biology* **16**, 155-167.

MUSAIGER, A.O. & HARFOUCHE. J. (1992). Breastfeeding in the Eastern Mediterranean Countries. WHO/ EMRO, Alexandria, Egypt.

MUSAIGER, A.O., MATTER, A.M., ALEKRI, S.A. & MAHDI, A.R. (1993). Obesity among secondary school students in Bahrain. *Nutrition & Health* **9**, 25-32.

MUST, A., DALLAL, G.E. & DIETZ, W.H. (1991). Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht2) and triceps skinfold thickness *American Journal of Clinical Nutrition* **53**, 839-846.

MUST, A., JACQUES, P.F., DALLAL, G.E., BAJEMA, C.J. & DIETZ, W.H. (1992). Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. *New England Journal of Medicine* **327**, 1350-1355.

MUST, A. & STRAUSS, R.S. (1999). Risks and consequences of childhood and adolescent obesity. *International Journal of Obesity & Related Metabolic Disorders* **23 Suppl 2**, S2-11.

NGUYEN, V.T., LARSON, D.E. & JOHNSON, R.K. (1996). Fat intake and adiposity in children of lean and obese parents. *American Journal of Clinical Nutrition* **63**, 507-513.

NIH (National Institute of health) (1996). Physical Activity and Cardiovascular Health. *JAMA* **276**, 241-246.

OKASHA, M., MCCARRON, P., MCEWEN, J. & DAVEY, S.G. (2000). Determinants of adolescent blood pressure: findings from the Glasgow University student cohort. *Journal of Human Hypertension* **14**, 117-124.

OLIVER, G. & WARDLE, J. (1999). Perceived effects of stress on food choice. *Physiology & Behavior* **66**, 511-515.

OLIVERIA, S.A., ELLISON, R.C., MOORE, L.L., GILLMAN, M.W. & SINGER, M.R. (1992). Parent-child relationships in nutrient intake: the Framingham Children's Study. *American Journal of Clinical Nutrition* **56**, 593-598.

OWENS, S., GUTIN, B., ALLISON, J., RIGGS, S., FERGUSON, M., LITAKER, M. & THOMPSON, W. (1999). Effect of physical training on total and visceral fat in obese children. *Medicine & Science in Sports & Exercise* **31**, 143-148.

PARSONS, T.J., POWER, C., LOGAN, S. & SUMMERBELL, C.D. (1999). Childhood predictors of adult obesity: a systematic review. *International Journal of Obesity* **23 Suppl 8**, S1-107.

PERUSSE, L. & BOUCHARD, C. (1999). Role of genetic factors in childhood obesity and in susceptibility to dietary variations. *Annals of Medicine* **31 Suppl 1**, 19-25.

PETTITT, D.J., BAIRD, H.R., ALECK, K.A., BENNETT, P.H. & KNOWLER, W.C. (1983). Excessive obesity in offspring of Pima Indian women with diabetes during pregnancy. *New England Journal of Medicine* **308**, 242-245.

PIETROBELLI, A., FAITH, M.S., ALLISON, D.B., GALLAGHER, D., CHIUMELLO, G. & HEYMSFIELD, S.B. (1998). Body mass index as a measure of adiposity among children and adolescents: a validation study. *Journal of Pediatrics* **132**, 204-210.

PINHAS-HAMIEL, O., DOLAN, L.M., DANIELS, S.R., STANDIFORD, D., KHOURY, P.R. & ZEITLER, P. (1996). Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. *Journal of Pediatrics* **128**, 608-615.

POSKITT, E.M. (1988). Adolescence. In *Practical Pediatric Nutrition*,. POSKITT, E.M. ed, pp. 275-290. Butterworths, UK.

POULIOT, M.C., DESPRES, J.P., LEMIEUX, S., MOORJANI, S., TREMBLAY, A., NADEAU, A. & LUPIEN, P.J. (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**, 460-468.

POWER, C., LAKE, J.K. & COLE, T.J. (1997). Measurement and long-term health risks of child and adolescent fatness. *International Journal of Obesity & Related Metabolic Disorders* **21**, 507-526.

POWER, C. & PARSONS, T. (2000). Nutritional and other influences in childhood as predictors of adult obesity. *Proceedings of the Nutrition Society* **59**, 267-272.

PRENTICE, A.M. & JEBB, S.A. (1995). Obesity in Britain: gluttony or sloth? *BMJ* **311**, 437-439.

PRENTICE, A. M. & JEBB, S. A. (2001). Beyond body mass index. *Obesity Reviews* **2**, 141-147.

PRITCHARD, M.E., KING, S.L. & D.M. (1997). Adolescent body mass indices and self-perception. *Adolescence* **32**, 863-880.

RAMES, L.K., CLARKE, W.R., CONNOR, W.E., REITER, M.A. & LAUER, R.M. (1978). Normal blood pressure and the evaluation of sustained blood pressure elevation in childhood: the Muscatine study. *Pediatrics* **61**, 245-251.

RASHEED, P. (1998). Perception of body weight and self-reported eating and exercise behaviour among obese and non-obese women in Saudi Arabia. *Public Health* **112**, 409-414.

RASMUSSEN, F. & 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., STEIN, Z.A. & SUSSER, M.W. (1976). Obesity in young men after famine exposure in utero and early infancy. *New England Journal of Medicine* **295**, 349-353.

RISCH, N. (1990). Linkage strategies for genetically complex traits. I. Multilocus models. *American Journal of Human Genetics* **46**, 222-228.

ROBERTS, S.J., MCGUINESS, P.J., BILTON, R.F. & MAXWELL, S.M. (1999). Dieting behavior among 11-15-year-old girls in Merseyside and the Northwest of England. *Journal of Adolescent Health* **25**, 62-67.

ROBINSON, T.N. (1999). Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA* **282**, 1561-1567.

ROBINSON, T.N. (2001). Television viewing and childhood obesity. *Pediatric Clinics of North America* **48**, 1017-1025.

ROBINSON, T.N., HAMMER, L.D., KILLEN, J.D., KRAEMER, H.C., WILSON, D.M., HAYWARD, C. & TAYLOR, C.B. (1993). Does television viewing increase obesity and reduce physical activity? Cross-sectional and longitudinal analyses among adolescent girls. *Pediatrics* **91**, 273-280.

ROBINSON, T.N., KIERNAN, M., MATHESON, D.M. & HAYDEL, K.F. (2001). Is parental control over children's eating associated with childhood obesity? Results from a population-based sample of third graders. *Obesity Research* **9**, 306-312.

ROCANDIO, A.M., ANSOTEGUI, L. & ARROYO, M. (2001). Comparison of dietary intake among overweight and non-overweight schoolchildren. *International Journal of Obesity* **25**, 1651-1655.

ROCCHINI, A.P., KEY, J., BONDIE, D., CHICO, R., MOOREHEAD, C., KATCH, V. & MARTIN, M. (1989). The effect of weight loss on the sensitivity of blood pressure to sodium in obese adolescents. *New England Journal of Medicine* **321**, 580-585.

ROGOL, A.D. (1994). Growth at puberty: interaction of androgens and growth hormone. *Medicine & Science in Sports & Exercise* **26**, 767-770.

ROLLAND-CACHERA, M.F. (1993). Body composition during adolescence: methods, limitations and determinants. *Hormone Research* **39 Suppl 3**, 25-40.

ROLLAND-CACHERA, M.F. & BELLISLE, F. (1986). No correlation between adiposity and food intake: why are working class children fatter? *American Journal of Clinical Nutrition* **44**, 779-787.

ROLLAND-CACHERA, M.F., BELLISLE, F. & DEHEEGER, M. (2000). Nutritional status and food intake in adolescents living in Western Europe. *European Journal of Clinical Nutrition* **54 Suppl 1**, S41-S46

ROLLAND-CACHERA, M.F., BELLISLE, F., PEQUIGNOT, F. & SEMPE, M. (1990). Influence of body fat distribution during childhood on body fat distribution in adulthood: a two-decade follow-up study. *International Journal of Obesity* **14**, 473-481.

ROLLAND-CACHERA, M.F., DEHEEGER, M., GUILLOUD-BATAILLE, M., AVONS, P., PATOIS, E. & SEMPE, M. (1987). Tracking the development of adiposity from one month of age to adulthood. *Annals of Human Biology* **14**, 219-229.

ROLLAND-CACHERA, M.F., SPYCKRELLE, Y. & DESCHAMPS, J.P. (1992). Evolution of pediatric obesity in France. *International Journal of Obesity & Related Metabolic Disorders.* **16**, 5

ROSENBAUM, M. & LEIBEL, R.L. (1998). The physiology of body weight regulation: Relevance to the etiology of obesity in children. *Pediatrics* **101**, 525-539.

SALLIS, J.F., NADER, P.R., BROYLES, S.L., BERRY, C.C., ELDER, J.P., MCKENZIE, T.L. & NELSON, J.A. (1993). Correlates of physical activity at home in Mexican-American and Anglo-American preschool children. *Health Psychology* **12**, 390-398.

SALLIS, J.F. & PATRICK, K. (1994). Physical activity guidelines for adolescents: consensus statement. *Pediatric Exercise Science* **6**(4), 302-314

SALLIS, J.F., PATTERSON, T.L., BUONO, M.J., ATKINS, C.J. & NADER, P.R. (1988a). Aggregation of physical activity habits in Mexican-American and Anglo families. *Journal of Behavioral Medicine* **11**, 31-41.

SALLIS, J.F., PATTERSON, T.L., MCKENZIE, T.L. & NADER, P.R. (1988b). Family variables and physical activity in preschool children. *Journal of Developmental Behavioural Pediatrics* **9**, 57-61.

SCHAEFER, F., GEORGI, M., WUHL, E. & SCHARER, K. (1998). Body mass index and percentage fat mass in healthy German schoolchildren and adolescents. *International Journal of Obesity & Related Metabolic Disorders* **22**, 461-469.

SCHULZ, L.O. & SCHOELLER, D.A. (1994). A compilation of total daily energy expenditures and body weights in healthy adults. *American Journal of Clinical Nutrition* **60**, 676-681.

SCIACCA, J.P., MELBY, C.L., HYNER, G.C., BROWN, A.C. & FEMEA, P.L. (1991). Body Mass Index and perceived weight status in young adults. *Journal of Community Health* **16**, 159-168.

SCOTT, I.U., SIATKOWSKI, R.M., ENEYNI, M., BRODSKY, M.C. & LAM, B.L. (1997). Idiopathic intracranial hypertension in children and adolescents. *American Journal of Ophthalmology* **124**, 253-255.

SEIDELL, J.C. (1995). Obesity in Europe. *Obesity Research* **3 Suppl** 2, 89s-93s.

SEIDMAN, D.S., LAOR, A., GALE, R., STEVENSON, D.K. & DANON, Y.L. (1991). 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., WILLIAMSON, D.F. & BYERS, T. (1993). Do obese children become obese adults? A review of the literature. *Preventive Medicine* **22**, 167-177.

SERENIUS, F. & FOUGEROUSE, D. (1981). Health and nutritional status in rural Saudi Arabia. *Saudi Medical Journal* **5**, 10-22 (supplement).

SHAW, M.E. (1998). Adolescent breakfast skipping: an Australian study. *Adolescence* **33**, 851-861.

SHEAR, C.L., FREEDMAN, D.S., BURKE, G.L., HARSHA, D.W. & BERENSON, G.S. (1987). Body fat patterning and blood pressure in children and young adults. The Bogalusa Heart Study. *Hypertension* **9**, 236-244.

SHEPHERD, R. & DENNISON, C.M. (1996). Influences on adolescent food choice. *Proceedings of the Nutrition Society* **55**, 345-357.

SINAIKO, A.R., JACOBS, D.R.J., STEINBERGER, J., MORAN, A., LUEPKER, R., ROCCHINI, A.P. & PRINEAS, R.J. (2001). Insulin resistance syndrome in childhood: associations of the euglycemic insulin clamp and fasting insulin with fatness and other risk factors. *Journal of Pediatrics* **139**, 700-707.

SLAUGHTER, M.H., LOHMAN, T.G., BOILEAU, R.A., HORSWILL, C.A., STILLMAN, R.J., VAN LOAN, M.D. & BEMBEN, D.A. (1988). Skinfold equations for estimation of body fatness in children and youth. *Human Biology* **60**, 709-723.

SOBAL, J. & STUNKARD, A.J. (1989). Socioeconomic status and obesity: a review of the literature. *Psychological Bulletin* **105**, 260-275.

SORENSEN, T.I., HOLST, C. & STUNKARD, A.J. (1992). Childhood body mass index--genetic and familial environmental influences assessed in a longitudinal adoption study. *International Journal of Obesity & Related Metabolic Disorders* **16**, 705-714.

SPRUIJT-METZ, D., LINDQUIST, C.H., BIRCH, L.L., FISHER, J.O. & GORAN, M.I. (2002). Relation between mothers' child-feeding practices and children's adiposity. *American Journal of Clinical Nutrition* **75**, 581-586.

SRINIVASAN, S.R., BAO, W., WATTIGNEY, W.A. & BERENSON, G.S. (1996). Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: the Bogalusa Heart Study. *Metabolism: Clinical & Experimental* **45**, 235-240.

SRINIVASAN, S.R., MYERS, L. & BERENSON, G.S. (2002). Predictability of childhood adiposity and insulin for developing insulin resistance syndrome (syndrome X) in young adulthood: the Bogalusa Heart Study. *Diabetes* **51**, 204-209.

STALLONES, L., MUELLER, W.H. & CHRISTENSEN, B.L. (1982). Blood pressure, fatness, and fat patterning among USA adolescents from two ethnic groups. *Hypertension* **4**, 483-486.

STEINBERGER, J., MOOREHEAD, C., KATCH, V. & ROCCHINI, A.P. (1995). Relationship between insulin resistance and abnormal lipid profile in obese adolescents. *Journal of Pediatrics* **126**, 690-695.

STEINBERGER, J., MORAN, A., HONG, C.P., JACOBS, D.R.J. & SINAIKO, A.R. (2001). Adiposity in childhood predicts obesity and insulin resistance in young adulthood. *Journal of Pediatrics* **138**, 469-473.

STETTLER, N., BOVET, P., SHAMLAYE, H., ZEMEL, B.S., STALLINGS, V.A. & PACCAUD, F. (2002). 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* **26**, 214-219.

STETTLER, N., TERSHAKOVEC, A.M., ZEMEL, B.S., LEONARD, M.B., BOSTON, R.C., KATZ, S.H. & STALLINGS, V.A. (2000). Early risk factors for increased adiposity: a cohort study of African American subjects followed from birth to young adulthood. *American Journal of Clinical Nutrition* **72**, 378-383.

STORY, M., FRENCH, S.A., RESNICK, M.D. & BLUM, R.W. (1995). Ethnic/racial and socioeconomic differences in dieting behaviors and body image perceptions in adolescents. *International Journal of Eating Disorders* **18**, 173-179.

STRAUSS, R. (1999). Childhood obesity. *Current Problems in Pediatrics* **29**, 1-29.

STUBBS, R.J., HARBRON, C.G., MURGATROYD, P.R. & PRENTICE, A.M. (1995). Covert manipulation of dietary fat and energy density: effect on substrate flux and food intake in men eating ad libitum. *American Journal of Clinical Nutrition* **62**, 316-329.

STUNKARD, A.J., HARRIS, J.R., PEDERSEN, N.L. & MCCLEARN, G.E. (1990). The body-mass index of twins who have been reared apart. *New England Journal of Medicine* **322**, 1483-1487.

STUNKARD, A.J., SORENSEN, T.I., HANIS, C., TEASDALE, T.W., CHAKRABORTY, R., SCHULL, W.J. & SCHULSINGER, F. (1986). An adoption study of human obesity. *New England Journal of Medicine* **314**, 193-198.

STUNKARD, A.J., SORENSEN, T. & SCHULSINGER, F. (1983). Use of the Danish Adoption Register for the study of obesity and thinness. *Research Publications - Association for Research in Nervous & Mental Disease* **60**, 115-120.

SUGERMAN, H.J., DEMARIA, E.J., FELTON, W.L.3., NAKATSUKA, M. & SISMANIS, A. (1997). Increased intra-abdominal pressure and cardiac filling pressures in obesity-associated pseudotumor cerebri. *Neurology* **49**, 507-511.

SUMMERBELL, C.D., MOODY, R.C., SHANKS, J., STOCK, M.J. & GEISSLER, C. (1995). Sources of energy from meals versus snacks in 220 people in four age groups. *European Journal of Clinical Nutrition* **49**, 33-41.

SUMMERBELL, C.D., MOODY, R.C., SHANKS, J., STOCK, M.J. & GEISSLER, C. (1996). Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. *European Journal of Clinical Nutrition* **50**, 513-519.

TASK FORCE ON BLOOD PRESSURE CONTROL IN CHILDREN (1987). Report of the Second Task Force on Blood Pressure Control in Children--1987. Task Force on Blood Pressure Control in Children. National Heart, Lung, and Blood Institute, Bethesda, Maryland. *Pediatrics* **79**, 1-25.

TAYLOR, R.W., JONES, I.E., WILLIAMS, S.M. & 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**, 490-495.

TAYLOR, W.C. & SALLIS, J.F. (1997). Determinants of physical activity in children. *World Review of Nutrition & Dietetics* **82**, 159-167.

TAZAWA, Y., NOGUCHI, H., NISHINOMIYA, F. & TAKADA, G. (1997). Serum alanine aminotransferase activity in obese children. *Acta Paediatrica* **86**, 238-241.

THAKUR, N. & D'AMICO, F. (1999). Relationship of nutrition knowledge and obesity in adolescence. *Family Medicine* **31**, 122-127.

TOMEO, C.A., J.W., MICHELS, K.B., BERKEY, C.S., HUNTER, D.J., FRAZIER, A.L., WILLETT, W.C. & BUKA, S.L. (1999). Reproducibility and validity of maternal recall of pregnancy-related events. *Epidemiology* **10**, 774-777.

TREUTH, M.S., BUTTE, N.F., ELLIS, K.J., MARTIN, L.J. & COMUZZIE, A.G. (2001). Familial resemblance of body composition in prepubertal girls and their biological parents. *American Journal of Clinical Nutrition* **74**, 529-533.

TROIANO, R.P., BRIEFEL, R.R., CARROLL, M.D. & 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**, 1343S-1353S.

TROIANO, R.P. & FLEGAL, K.M. (1998). Overweight children and adolescents: Description, epidemiology and demographics. *Pediatrics* **101**, 497-504.

TROST, S.G., KERR, L.M., WARD, D.S. & PATE, R.R. (2001). Physical activity and determinants of physical activity in obese and non-obese children. *International Journal of Obesity* **25**, 822-829.

TUCKER, L.A. (1985). Dimensionality and factor satisfaction of the body image construct: a gender comparison. *Sex Roles* **12**, 931-937.

TULLDAHL, J., PETTERSSON, K., ANDERSSON, S.W. & HULTHEN, L. (1999). Mode of infant feeding and achieved growth in adolescence: early feeding patterns in relation to growth and body composition in adolescence. *Obesity Research* **7**, 431-437.

ULIJASZEK, S. & LOURIE, J. (1994). Intra- and inter-observer error in anthropometric measurement. In *Anthropometry: the individual and the population*, eds. ULIJASZEK, S.J. & MASCIE-TAYLOR, C.G., pp. 30-53. Cambridge University Press.

US DEPARTMENT OF HEALTH AND HUMAN SERVICES (1996). Guidelines for school health programs to promote lifelong healthy eating. *Morbidity Mortality Weekly Report (MMWR)* **45**, 1-40.

VAN LENTHE, F.J., KEMPER, C.G. & 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.

VILA, G., ROBERT, J.J., NOLLET-CLEMENCON, C., VERA, L., CROSNIER, H., RAULT, G., JOS, J. & M.C. (1995). Eating and emotional disorders in adolescent obese girls with insulin-dependent diabetes mellitus. *European Child & Adolescent Psychiatry* **4**, 270-279.

VON KRIES, R., KOLETZKO, B., SAUERWALD, T., VON MUTIUS, E., BARNERT, D., GRUNERT, V. & VON VOSS, H. (1999). Breast feeding and obesity: cross sectional study. *BMJ* **319**, 147-150.

WARDLE, J., STEPTOE, A., OLIVER, G. & LIPSEY, Z. (2000). Stress, dietary restraint and food intake. *Journal of Psychosomatic Research* **48**, 195-202.

WESTSTRATE, J.A., DEURENBERG, P. & VAN TINTEREN, H. (1989). Indices of body fat distribution and adiposity in Dutch children from birth to 18 years of age. *International Journal of Obesity* **13**, 465-477.

WHITAKER, R.C. & DIETZ, W.H. (1998). Role of the prenatal environment in the development of obesity. *Journal of Pediatrics* **132**, 768-776.

WHITAKER, R.C., WRIGHT, J.A., PEPE, M.S., SEIDEL, K.D. & DIETZ, W.H. (1997). Predicting obesity in young adulthood from childhood and parental obesity. *New England Journal of Medicine* **337**, 869-873.

WHO (1989). Clinical Disorders arising from dietary affluence in countries of the Eastern Mediterranean Region. 14. World Health Organization, Regional Office in the Eastern Mediterranean, Alexandria, Egypt.

WHO (1990). Prevention in childhood and youth of adult cardiovascular diseases: time for action. WHO technical report series 792, pp83-95. World Health Organization, Geneva.

WHO (1994). WHO Expert Committee on Hypertension Control. www.who.int/acd/cvd/trs862.html#tableg, World Health Organization, Geneva.

WHO (1995). Physical status: the use and interpretation of anthropometry. WHO Technical Report Series 854. World Health Organization, Geneva.

WHO (2000). Obesity: preventing and managing the global epidemic. WHO Technical Report Series 894. World Health Organization, Geneva.

WILLIAMS, D.P., GOING, S.B., LOHMAN, T.G., HARSHA, D.W., SRINIVASAN, S.R., WEBBER, L.S. & 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.

WILLIAMS, S. (2001). Overweight at age 21: the association with body mass index in childhood and adolescence and parents' body mass index. A cohort study of New Zealanders born in 1972- 1973. *International Journal of Obesity* **25**, 158-163.

WILSON, S.L., GAFFNEY, F.A., LAIRD, W.P. & FIXLER, D.E. (1985). Body size, composition, and fitness in adolescents with elevated blood pressures. *Hypertension* **7**, 417-422.

WISEMAN, C.V., GRAY, J.J., MOSIMANN, J.E. & AHRENS, A.H. (1992). Cultural expectations of thinness in women: An update. *International Journal of Eating Disorders* **11**, 85-89.

WOLF, A.M., GORTMAKER, S.L., CHEUNG, L., GRAY, H.M., HERZOG, D.B. & COLDITZ, G.A. (1993). Activity, inactivity, and obesity: racial, ethnic, and age differences among schoolgirls. *American Journal of Public Health* **83**, 1625-1627.

WONG, W.W., STUFF, J.E., BUTTE, N.F., SMITH, E.O. & ELLIS, K.J. (2000). Estimating body fat in African American and white adolescent girls: a comparison of skinfold-thickness equations with a 4-compartment criterion model. *American Journal of Clinical Nutrition* **72**, 348-354.

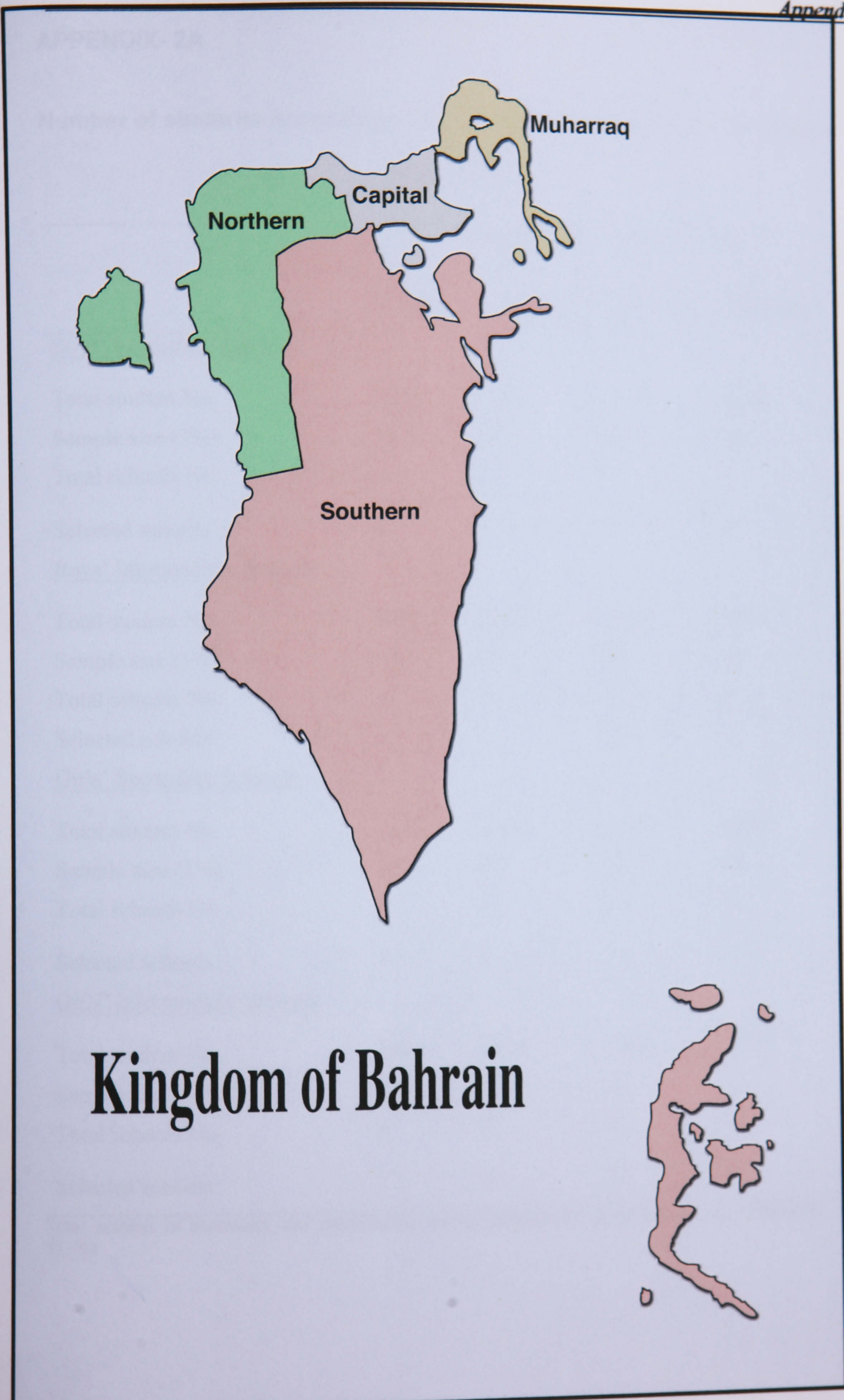
WRIGHT, C.M., PARKER, L., LAMONT, D. & CRAFT, A.W. (2001). Implications of childhood obesity for adult health: findings from thousand families cohort study. *BMJ* **323**, 1280-1284.

YASIN, A. (1998). Time Expenditure. National center for Social and Crime Studies. Cairo, Egypt (in Arabic).

ZAGHLOUL, N.E., AL-SHERBINI, A.F. & AL-SHAYEB, F.A. (1984). Dietary factors and physical activity of obese and non-obese adolescent girls. *Bulletin of High Institute of Public Health (Alexandria)* **14**, 31-49.

APPENDIX- 1A


Nicosia
CYPRUS
LEBANON
SYRIA
Mediterranean Sea
Beirut
Damascus
Tehran
Baghdad
IRAQ
ISRAEL
Jerusalem
Amman
JORDAN
KINGDOM OF
BAHRAIN
IRAN
KUWAIT
PAK.
Arabian
Gulf
EGYPT
BAHRAIN
QATAR
Riyadh
Abu
Dhabi
Gulf of Oman
SAUDI
ARABIA
UNITED ARAB
EMIRATES
Muscat
OMAN
Mecca
Red
Sea
SUDAN
Arabian Sea
Sanaa
YEMEN
Socotra
ETHIOPIA
Aden
Gulf of Aden
DJIBOUTI
SOMALIA
0
500 Nautical Miles


Muharraq
Capital
Northern
Southern
Kingdom of Bahrain

APPENDIX- 2A

Number of students according to the geographic distribution of schools in Bahrain

	Geographic Area (Governorate)				
	Capital	Muharraq	Northern	Southern	Total
Boys' Secondary Schools					
Total student No.	3796	1730	1504	4248	11,278
Sample size (1%)	38	17	15	42	112
Total schools No.	6	2	2	3	13
Selected schools	2	1	1	2	6
Boys' Intermediate Schools					
Total student No.	1931	2260	5167	4933	14,291
Sample size (1%)	19	23	52	49	143
Total schools No.	5	5	8	9	27
Selected schools	1	1	2	2	6
Girls' Secondary Schools					
Total student No.	2575	1884	3085	4981	12,525
Sample size (1%)	26	19	31	50	126
Total schools No.	3	4	3	5	15
Selected schools	1	1	2	2	6
Girls' Intermediate Schools					
Total student No.	1849	2215	5204	5392	14,660
Sample size (1%)	18	22	52	54	146
Total schools No.	4	7	8	8	27
Selected schools	1	1	2	2	6

Total number of secondary and intermediate school students for the academic year 2000-2001 = 52,754

APPENDIX- 2B

Selected schools and sample size

	School	Sample size
Boys' Secondary Schools		
1	Ahmed Al-Omran	21
2	Shaikh Abdulaziz	21
3	Al-Hedaya Al-Khalifiya	18
4	Hamad Town	18
5	Isa Town	21
6	East Riffa	21
Boys' Intermediate Schools		
7	Al-Quadiabeya	21
8	Tariq Bin Zeyad	24
9	Jid Hafs	27
10	Al-Farabi	27
11	Othman Bin Affan	24
12	West Riffa	24
Girls' Secondary Schools		
13	Khawla	27
14	Al- Muharraq	21
15	Saar	15
16	Hamad Town	15
17	Al- Noor	24
18	West Riffa	24
Girls' Intermediate Schools		
19	Om Salema	18
20	Zanobia	21
21	Al-Doraz	27
22	Al-Qairwan	27
23	Sitra	27
24	East Riffa	27
	TOTAL SAMPLE SIZE	**540**

APPENDIX- 3A

Information Sheet (*English translation of the original in Arabic)*

Research title: Prevalence and determinants of obesity among adolescents in Bahrain.

Dear student/ parent,

We are going to conduct a study on Bahraini adolescents between 12-17 years of age. The project is aimed at determining the prevalence of obesity among schoolchildren and factors contributing to its development. We will visit your school one time only to collect the following information:

1. We will measure your weight, height, waist circumference, hip circumference and arm circumference with your clothes on. We will also measure your blood pressure as well as the fat mass around your arm and at the back using a small harmless instrument. All measurements will be taken by a specialist of the same sex as you and will be taken behind a screen to ensure your privacy.
2. We will also give you a questionnaire to fill out containing general questions as well as questions about your eating habits, physical activity and life style.

All information you give us will be handled confidentially and no one but the research team will have access to it. The information will be coded, entered into a computer and stored. The results of the study will be communicated to you and to the Ministry of Health. We hope that the findings will help to design a better health programme to prevent obesity among children and adolescents in Bahrain.

APPENDIX- 3B

Consent Form (English translation of the original in Arabic)

Research title: Prevalence and determinants of obesity among adolescents in Bahrain

I have read the information sheet concerning this study and I understand what will be required of me if I take part in the study. My questions concerning this study have been answered by the study investigator, Ms. Aneesa Al-sendi.

I understand that at any time I may withdraw from this study without giving a reason and without any effects on me.

I agree to take part in this study.

Signature of student----------------------------

Signature of parent-------------------------------

Date:---

APPENDIX- 4A (English translation of the original in Arabic)

Questionnaire of the Prevalence Study

SECTION I: GENERAL INFORMATION CODE /_/_/_/

Name: --

School: -- Class:---------------

Home phone:------------------------

Nationality: (1) Bahraini (2) Non Bahraini

---

1. Sex: (1) Male (2) Female
2. Age: ------------completed years Date of birth: ---------------------(day, month, year)
3. Father's occupation: ----------------------
4. Mother's occupation: ---------------------
5. Father's education: (1) Illiterate (2) read & write (3) primary (4) elementary (5) secondary (6) college (7) I do not know/not applicable
6. Mother's education: (1) Illiterate (2) read & write (3) primary (4) elementary (5) secondary (6) college (7) I do not know/not applicable
7. How many brothers & sisters have you got? -----------

SECTION II: INFORMATION ON DIETARY HABITS:

8. How many main meals do you eat per day? -------
9. Do you normally eat breakfast? (1)Yes (2) No (3)Sometimes
10. Do you normally eat a morning snack?

    (0) I don't eat (1) I eat: --

11. Do you normally eat an afternoon snack?

(0) I don't eat (1) I eat: ---

12. Do you normally eat before going to bed (after dinner)?

(0) I don't eat (1) I eat: ---

For each food item, indicate with a check mark (✓) the category that best describes the frequency with which you usually eat that particular food item:

Food item	More than once per day (1)	Once a day (2)	4-6 times per week (3)	1-3 times per week (4)	Once a month or less (5)
13. Eggs					
14. Cheese					
15. Legumes, beans, peas					
16. Milk					
17. Beef burger					
18. Fried chicken					
19. Pizza					
20. French fries					
21. Salad					
22. Fruits					
23. Fruit juice					
24. Flavoured drinks					
25. Carbonated beverages					
26. Nuts					
27. Potato crisps/puffed corn					
28. Chocolates					
29. Candies					
30. Ice cream					

How frequently do the following eating behaviours occur for you: Tick as appropriate.

Behaviour	Always (1)	Frequently (2)	Sometimes (3)	Rarely (4)
31. Eat meals while watching the TV				
32. Eat when bored				
33. Eat when angry/upset /negative mood				
34. Eat snacks late at night				

35. Do you have your main meal (lunch):

(1) alone (2) with your parents or other members of the family

36. At the main meal do you eat directly from:

(1) your own separate plate (2) A common plate shared with other family members

37. Do you have your meals while:

(1) watching the TV (2) without watching TV

38. When it is mealtime and you are not hungry what would you do?

(1) not eat (2) eat less (3) eat the same

39. Have you ever asked for or bought sweets/snacks you saw advertised on TV:

(1) always (2) frequently (3) sometimes (4) never

40. How often do you eat fruits:

(1) every day (2) many times a week (3) occasionally (4) rarely

41. How often do you eat meals with your family:

(1) always (2) frequently (3) sometimes (4) never

42. About how many times per week do you eat in fast food restaurant?

(0) I don't eat (1) I eat: -----times/week

43. About how many times per week do you eat take away fast foods?

(0) I don't eat (1) I eat: -----times/week

SECTION III: INFORMATION REGARDING KNOWLEDGE & ATTITUDES ABOUT NUTRITION

In your opinion what causes weight gain?

44. Overeating: (1) yes (2) no (3) I don't know

45. Too much fatty food: (1) yes (2) no (3) I don't know

46. Too many sweets: (1) yes (2) no (3) I don't know

47. Not enough exercise: (1) yes (2) no (3) I don't know

48. Parents' weight (heredity): (1) yes (2) no (3) I don't know

Indicate with an (X) mark, how much in your opinion one should eat of the following foods in order to be fit and healthy:

	V. Little amounts (1)	Little amounts (2)	Moderate amounts (3)	Large amounts (4)	Very large amounts (5)
49. Rice and bread					
50. Meat					
51. Fruits and Vegetables					
52. Milk and milk products					
53. Fatty foods					
54. Sweets					

Do you think the following statements are true, false or you don't know? Tick (✓) as appropriate.

Statement	True (1)	False (2)	I Do not know (3)
55. Drinking too much water causes a big stomach			
56. Skipping breakfast helps in weight loss			
57. Steam baths and saunas help in weight loss			
58. Grapefruit juice helps in dissolving excess fat			
59. Drinking tea and coffee helps in weight loss			
60. Men like women to be slightly overweight.			
61. Mental activities such as studying and playing video/computer games burn lots of calories.			

SECTION IV: INFORMATION ON LIFE STYLE

62. How do you go to school?
 (1) walking (2) cycling (3) by car or bus

63. Do you participate in school PE classes?
 (1) always (2) sometimes (3) rarely

64. How often do you play sport outside school (during leisure time)?
 (1) seldom (2)sometimes (3) frequently

65. On average, how many hours do you sleep in a day? -------

Indicate with an X mark the duration and the frequency with which you engage in the following activities:

Type of Activity (Over the last month)		No	Yes	
			Times/week	Duration (hrs/min)
66	Walking			
67	Jogging			
68	Football			
69	Bicycle riding			
70	Aerobics			
71	Swimming			
72	Other sport, specify----------------			
73	Household chores (e.g sweeping)			
74	Playing outdoor (active games)			
75	Playing indoor (sedentary games)			
76	Reading, writing, homework			

How many hours per day do you spend watching TV or video?

77. On school days: (1) I watch ------hours/day (0) I do not watch

78. On weekend days:(1) I watch ------hours/day (0) I do not watch

How many hours per day do you spend playing video/computer games?

79. On school days:(1) I play ------hours/day (0) I do not play

80. On weekend days: (1) I play ------hours/day (0) I do not play

81. Do you smoke?
(1) Yes (2) No

82. If yes, how many cigarettes per day? ----------

SECTION V: HEALTH INFORMATION

83. Have you ever been told by your doctor that you suffer from a chronic disease or health problem? (0) no (1) yes

84. If yes, what is it?---

Do your parents suffer from the following diseases?

85. Diabetes (1) father (2) mother (3) both (4) neither (5) don't know
86. Heart disease (1) father (2) mother (3) both (4) neither (5) don't know
87. High blood pressure (1) father (2) mother (3) both (4) neither (5) don't know

SECTION VI: INFORMATION REGARDING BODY IMAGE & DIETING

88. Do you think you are:
    (1) thin (2) about right (3) fat (4) too fat (5) don't know

89. How do you feel about your weight? Are you:
    (1) content (2) discontent (3) I have never thought about it

90. What do your parents think of your weight? Do they think you are:
    (1) thin (2) about right (3) fat (4) too fat (5) I do not know

91. What do your peers/best friends think of your weight? Do they think you are:
    (1) thin (2) about right (3) fat (4) too fat (5) I do not know

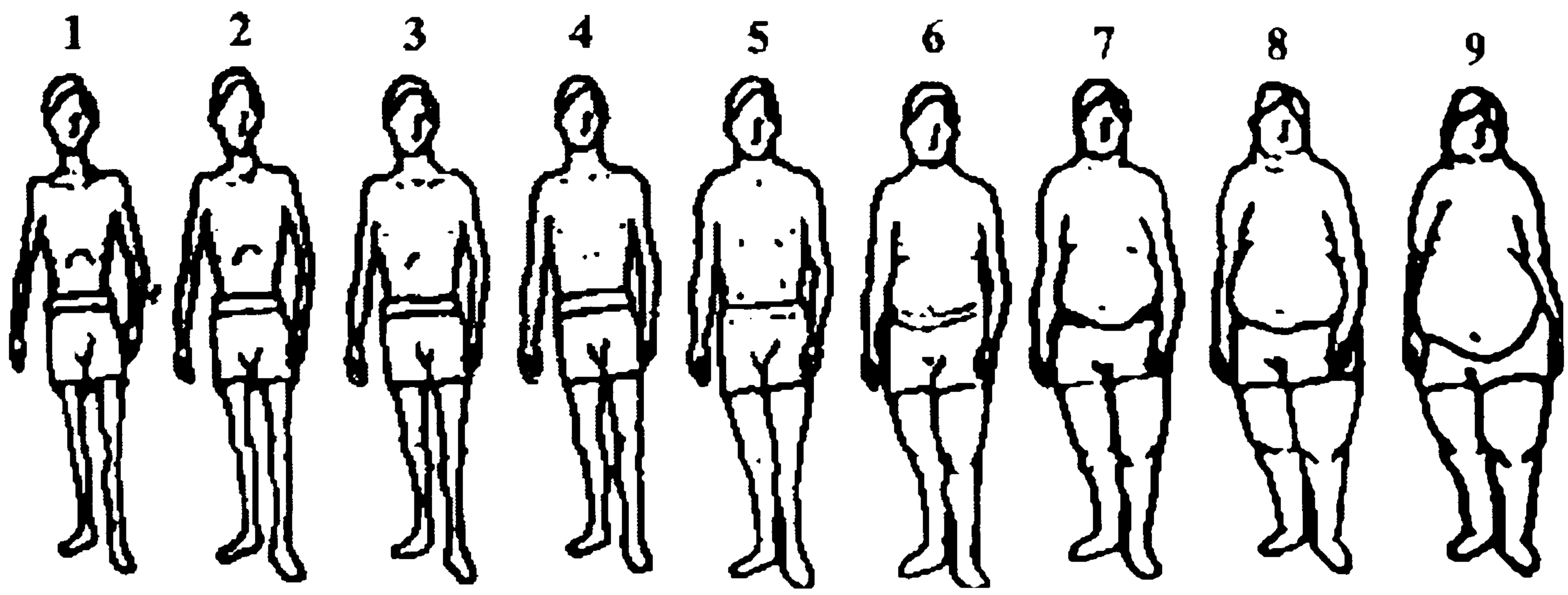
92. Have you ever tried to lose weight?
    (1) yes (2) no

93. Have you ever tried to gain weight?
    (1) yes (2) no

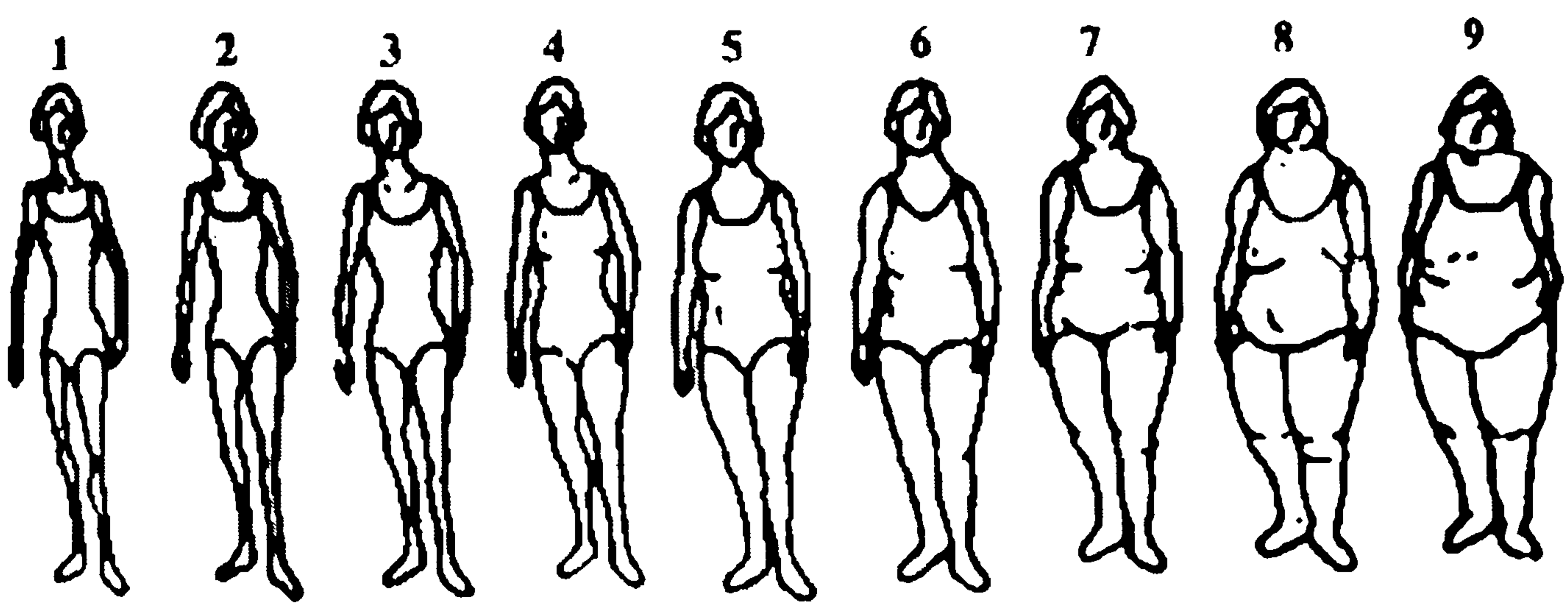
94. Which of the following figures is most like you now? ----------------

95. Which figure would you most like to look like?------------------------

Figures used in questionnaire for boys



Figures used in questionnaire for girls



ANTHROPOMETRIC MEASUREMENTS RECORDING FORM

Blood pressure:

Measurement	Readings		Average	Remarks
	1st	2nd		
96. Systolic BP				
97. Diastolic BP				

Height, weight & circumferences:

Measurement	Readings		Average	Remarks
	1st	2nd		
98. Height				
99. Weight				
100. Waist circumference				
101. Hip circumference				
102. Mid upper arm circumference.				

Skinfold Measurement:

Measurement	Readings			Average	Remarks
	1st	2nd	3rd		
103. Triceps skinfold					
104. Subscapular skinfold					
105. Medial calf					

APPENDIX – 4B *(English translation of the original in Arabic)*

Questionnaire of the Family Environment Study

CODE: /_/_/_/

1. Child's Name: -- 2. Sex: -----------------

3. Age: ------------------------------ Date of Birth:---------------------------------(dd/mm/yy)

4. Informant's name: -------------------------------------& relationship to child:----------------

Home telephone: ------------------Home address: --

Interviewer's Name -------------------------------------Interview Date: ----------------------

SECTION II: SOCIODEMOGRAPHIC CHARACTERISTICS

5. How many other children do you have (apart from the study child)?----------

6. What is the birth order of the child? ----------------------------

7. Mother alive: (1) Yes (2) No

8. Father alive: (1) Yes (2) No

9. Mother's age: ------------years

10. Father's age: ------------years

11. Marital status: (1) Married (2) Divorced (3) Widowed

12. Father's education: (1) Illiterate (2) Read & write (3) Primary (4) Elementary
(5) Secondary (6) College

13. Mother's education: (1) Illiterate (2) Read & write (3) Primary (4) Elementary
(5) Secondary (6) College

14. Father's occupation: (0) Do not work (1) Work: ---------------------------------------

15. Mother's occupation: (0) Do not work/ housewife (1) Work: -------------------------

16. Does your family own a car? (0) No (1) Yes
If yes, how many?-----------------

17. Does your family have a servant / housemaid? (0) No (1) Yes.
If yes, how many? ---------------

SECTION III: INFORMATION ON CHILD'S EATING HABITS:

18. What was the child's birth weight? ---------------kg
(In case the hospital discharge card is not available please give the name of the maternit, hospital and CPR no: ---)

19. What was the type of milk given to the child during the first 6 months of his/her life?
(1) Breast milk (2) formula (bottle) milk (3) both breast and formula milk

20. How would you respond if it's mealtime and your child is not hungry?
(1) Leave child alone
(2) You suggest that the child should eat less
(3) You convince the child to eat normally
(4) Other response, please specify:---

21. Has your child ever asked for or bought sweets or snacks he/she saw advertised on the TV:
(1) Frequently (2) Sometimes (3) Rarely

22. Have you ever encouraged your child to eat a particular type of food?
(0) No (1) Yes; What is it? ---

23. If the answer is yes, why do you encourage your child to eat this particular food?
(1) Because you think it's good (healthy) for the child
(2) Because you think it will make the child lose weight
(3) Because you think it will make the child gain weight
(4) Other reasons: ---

24. Have you ever discouraged your child from eating a particular type of food?
(0) No (1) Yes; What is it? ---

25. If the answer is yes, why do you discourage your child from eating this particular food?
(1) Because you think it's bad (unhealthy) for the child
(2) Because you think it will make the child lose weight
(3) Because you think it will make the child gain weight
(4) Other reasons: ---

26. Have you ever given your child food as a kind of reward?
(1) Frequently (2) Sometimes (3) Rarely

27. Have you ever denied your child a particular kind of food as a kind of punishment?
(1) Frequently (2) Sometimes (3) Rarely

28. Have you ever used verbal prompts to increase your child's eating?
(1) Frequently (2) Sometimes (3) Rarely

SECTION IV: INFORMATION ON INFORMANT PARENT'S EATING HABITS

In general, how many times do you eat the following foods? Tick as appropriate

Type	more than once per day (1)	once a day (2)	4-6 times per week (3)	1-3 times per week (4)	once a month or less (5)
29. Red meat					
30. Fish					
31. Salad					
32. Fruits					
33. Sweets					

34. Do you eat breakfast?
(1) Always (2) No (3) Occasionally

35. Do you eat out (in restaurants)?
(0) No (1) Yes
If yes, how often? -------------------times per ☐ Week ☐ Month

36. Do you eat take-away foods?
(1) No (1) Yes
If yes, how often? -------------------times per ☐Week ☐ Month

How frequently do the following eating behaviours occur for you? ✓ as appropriate

	Behaviour	Always (1)	Frequently (2)	Sometimes (3)	Never (4)
37	Eating meals while watching the TV				
38	Eating when bored				
39	Eating when upset/angry/negative mood				
40	Eat late Eating snacks late at night				

41. How often do you or your spouse eat the main meal (lunch) with the child?
(1) Always (2) Frequently (3) Sometimes (4) Rarely or never

42. Usually, do you have the main meal while:
(1) Watching the TV (2) Without watching the TV

Which of the following sweets/snacks are <u>usually</u> found in your home? Tick as appropriate:

43. ☐ Candy
44. ☐ Cake
45. ☐ Halwa (traditional sweet)
46. ☐ Rahash (traditional sweet)
47. ☐ Chocolate
48. ☐ Biscuits/Cookies
49. ☐ Ice cream
50. ☐ Nuts
51. ☐ Pastries
52. ☐ Potato crisps / Puffed corn
53. ☐ Carbonated beverages (e.g. Pepsi)
54. ☐ Flavoured drinks

55. In relation to the child's access, you usually keep the snacks and sweets in your home in:
    (1) A hiding place (2) Known but not seen place (3) Reachable place

56. To what degree can your child eat sweets/snacks without your knowledge/ permission?
    (1) Frequently (2) Sometimes (3) Rarely or never

57. Usually when the child eats sweets/snacks
    (1) He/she asks for it
    (2) The snack/sweet is offered by parents
    (3) He/she buys or helps himself to it

58. In your house how often are fresh fruits available?
    (1) Always (2) Most of the time (3) Sometimes (4) Rarely

<u>SECTION V: INFORMATION REGARDING PARENTS' KNOWLEDGE OF NUTRITION:</u>

In your opinion, what causes weight gain (obesity)?

59. Overeating: (1) Yes (2) No (3) I don't know

60. Too much fatty food /sweets: (1) Yes (2) No (3) I don't know

61. Not enough exercise: (1) Yes (2) No (3) I don't know

62. Parents' weight (heredity): (1) Yes (2) No (3) I don't know

Indicate with an (X) mark, how much in your opinion one should eat of the following foods:

	V. Little amount (1)	Little amount (2)	Moderate amount (3)	Large amount (4)	V. Large amount (5)
63. Rice and bread					
64. Meat					
65. Fruits and vegetables					
66. Milk and milk products					
67. Fatty foods					
68. Sweets					

Do you think the following statements are true, false or you don't know? Tick (✓) as appropriate.

	Statement	True (1)	False (2)	I Do not know (3)
69	Drinking too much water causes big a stomach			
70	Skipping breakfast helps in weight loss			
71	Steam baths and sauna help in weight loss			
72	Grapefruit juice helps in dissolving excess fat			
73	Drinking tea and coffee helps in weight loss			
74	Men like women to be slightly overweight			
75	Mothers like their children to be plump			
76	Mental activities such as studying and playing Video /computer games help in weight loss			

SECTION VI: INFORMATION ON INFORMANT PARENT PHYSICAL ACTIVITY

77. In addition to your daily life activities do you do exercise? (1) Yes (2) No

78. If yes, what type of exercise do you do? --

79. And how often? (1) Every day (2) 5-6 times/week (3) 3-4 times/week
(4) 1-2 times/week (5) 1-2 times/ month

80. How many hours on average do you spend watching TV or video during weekdays? -------------------- hours /day

81. How many hours, on average, do you spend watching TV or video during weekend days? -------------------- hours / day

82. During leisure time, do you engage in any sport?
(1) Often (2) Sometimes (3) Rarely

83. Have you ever used verbal prompts to increase child's physical activity?
(1) Frequently (2) Sometimes (3) Rarely

Please tell me what activities did your child do and how much time did he spend doing them from the moment he woke up yesterday or (last weekend) till he went to bed:

Activities done (minutes)			
School day		**Weekend day**	
Activity	**duration**	**Activity**	**duration**
-			
-			
-			
-			
-			
-			
-			
-			
-			
-			
-			
-			
Bed time		Bed time	

-How many hours does your child sleep during school days? ----------Hours/day

-How many hours does your child sleep during weekend days? -------Hours/day

Coding: (84-91)

	Physically demanding	Sedentary activities	Daily life activities	Sleeping/resting
School day	84)	85)	86)	87)
Weekend day	88)	89)	90)	91)

SECTION VII: HEALTH INFORMATION

92. Does your child have an obese relative?

(1) Yes (2) No (3) Don't know

If yes, who?

93. Siblings (1) Yes (2) No

94. Parents (1) Yes (2) No

95. Grand parents (1) Yes (2) No

96. Aunts/uncles (1) Yes (2) No

Have you been told by the doctor that you have the following diseases?

Mother

97. Obesity (1) Yes (2) No

98. Heart disease (1) Yes (2) No

99. Diabetes (1) Yes (2) No

100. High blood pressure (1) Yes (2) No

Father

101. Obesity (1) Yes (2) No

102. Heart disease (1) Yes (2) No

103. Diabetes (1) Yes (2) No

104. High blood pressure (1) Yes (2) No

SECTION VIII: INFORMATION REGARDING BODY IMAGE:

105. Do you think your child is?

(1) Thin (2) About right (3) Fat (4) Too fat (5) Don't know

106. How do you feel about your child's weight? Are you?

(1) Content (2) Discontent (3) Never thought about it

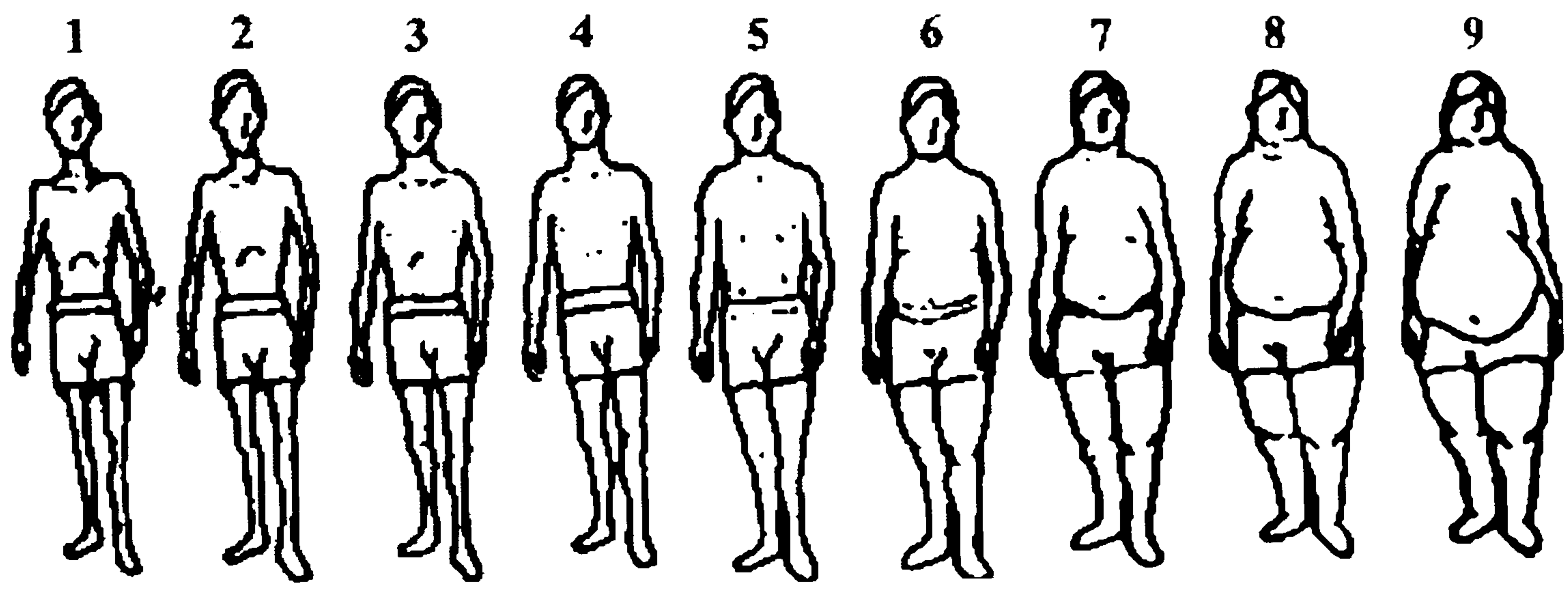
107. Have you ever tried to make your child lose weight? (1) Yes (2) No

108. Have you ever tried to make your child gain weight? (1) Yes (2) No

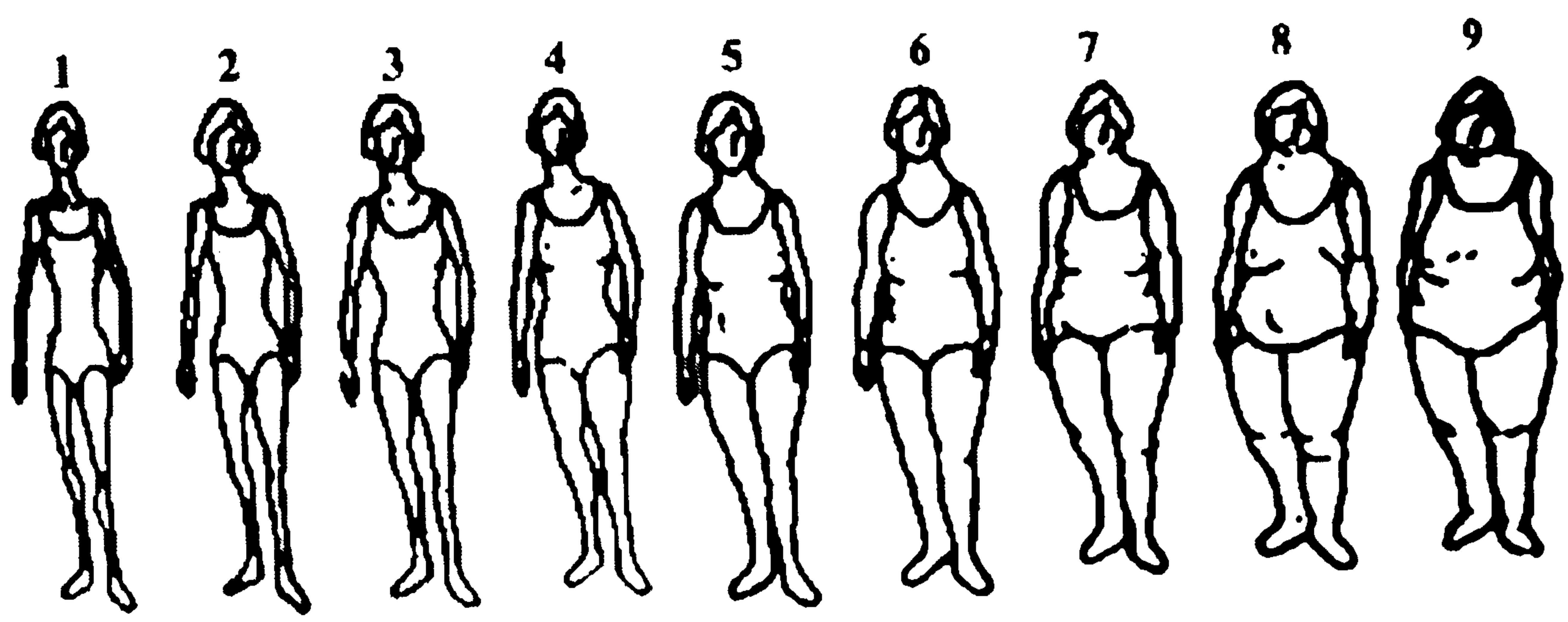
109. Which of the line drawings below, in your opinion, is most like your child now? ----

110. And which figure you would most like your child to look like? -------------

BOYS:



GIRLS:



PARENTS' HEIGHT AND WEIGHT RECORDING FORM:

Mother	**1st Reading**	**2nd Reading**	**Average**
111. Height			
112. Weight			
Father			
113. Height			
114. Weight			

APPENDIX 5

Reliability Statistics for Anthropometric Measurements

(For period mid-way through fieldwork)

	TECHNICAL ERROR OF MEASUREMENT	
	Measurer A	Measurer B
INTRA-OBSERVER		
MUAC (cm)	0.1	0.1
WC (cm)	0.2	0.2
HC (cm)	0.2	0.3
TSKF (mm)	0.6	0.3
SSKF (mm)	0.4	0.5
CSKF (mm)	0.5	-
INTER-OBSERVER*		
MUAC (cm)	0.3	0.2
WC (cm)	0.5	0.3
HC (cm)	0.2	0.4
TSKF (mm)	0.4	0.6
SSKF (mm)	0.6	0.7
CSKF (mm)	0.5	-

*Principal investigator and measurer

KEY: Measurer A = person who conducted measurements on all male subjects
Measurer B = person who conducted measurements on all female subjects
MUAC = mid upper arm circumference, WC= waist circumference, HC hip circumference
TSKF= triceps skinfold, SSKF= subscapular skinfold, CSKF= calf skinfold

	TECHNICAL ERROR OF MEASUREMENT
INTRA-OBSERVER	
Height (cm)	0.1
Weight (kg)	0.1
INTER-OBSERVER*	
Height (cm)	0.2
Weight (kg)	0.1

* Principal investigator and measurer

APPENDIX 6

Anthropometry and Blood Pressure Measurement Handout

This handout describes the procedures that will be used in the workshop to take the following measurements on male and female adolescents: Weight, height, mid upper arm circumference, skinfold thickness, waist circumference, hip circumference and blood pressure measurements.

1. Weight

For weight measurement you will use an electronic scale. The subjects' weight will be measured to the nearest 0.1Kg as follows:

1. Ask the subject to take off his/her shoes and socks
2. Tap once on the center of the scale (with your foot). The scale will be switched on and 188.8 will appear, then the display will jump to zero and the scale will be ready for weighing.
3. Ask the subject to step into the centre of the platform, stand relaxed but still and looking straight ahead.
4. The display will flash rapidly signalling the weight, which will appear on the display for 15 seconds.

2. Height

For height measurement you will use a height meter. The student's standing height will be measured to the nearest 0.1 centimetre as follows.

1. Ask the subject to stand without shoes, heels together, knees and back straight, head in an upright position and looking straight ahead. (To aid the straightening of the spine, ask the student to take a deep breath and stand tall).
2. Lower the movable head-board till it firmly touches the upper part of the subject's head and then take the height reading (use a stool if the subject is taller than you).

3. Body circumference

For taking the waist, hip and arm circumferences you will use a measuring tape. All the measurement will be taken to the nearest 0.1 cm

3.1. Waist circumference:

1. Ask the subject to stand erect, abdomen relaxed, arms at the sides and feet together.
2. Place the measuring tape horizontally at the level of the natural waist, which is mid-way between the lower margin of the ribs and the upper edge of the pelvis.

3.2. Hip circumference:

1. Ask the subject to stand erect, abdomen relaxed, arms at the sides and feet together.
2. Place the tape over the maximum extension of the buttocks. It may be necessary to move the tape up and down until the widest point is identified.

3.3. Mid upper arm circumference:

1. Ask the subject to stand at ease with the arm uncovered up to the shoulder.
2. Find the midpoint of the back of the left arm.
3. To do this, first identify the acromion process of the scapula (the most lateral bony point of the shoulder). Put the zero of the tape here.
4. Then ask the subject to bend his/her arm at 90 degrees and identify the olecranon process of the ulna (the central bony point of the elbow).
5. Let the arm hang loosely by the side, then read the length from the acromion to olecranon. Divide by 2 to find the mid point of the back of the upper arm then mark this level using a felt pen.
6. With the subject's arm relaxed and hanging at the side and palm facing inwards, pass the tape around the arm at the marked level so that it is touching the skin but not compressing the tissue.

4. Skinfold thickness measurement:

Skinfold thickness will be measured using a skinfold caliper. The measurement should be taken to the nearest 0.2 mm, on the left side and at the following anatomical locations:

- Triceps: Back of the upper arm at midpoint
- Subscapular: just below and lateral to the bottom angle of the scapula
- Calf: medial side of the lower leg at the level of maximal circumference.

You need to take 3 readings at each of these sites.

To pick up the skinfold (left hand):

1. Put the left thumb and forefinger on the skin about 1 cm above the selected site and 4-6 cm apart.
2. Move the thumb and forefinger towards each other to pick up a layer of skin and subcutaneous tissue which is fairly mobile relative to the underlying muscle and bone.
3. Keep gentle but firm pressure on this fold until the calipers have been applied and then removed.

To use the calipers (right hand):

1. Ensure that the dial of the calipers reads zero, if not adjust it.
2. Take the handle of the calipers in the palm of the right hand with the dial uppermost, and open the jaws to 8-10 cm.
3. Position the calipers jaws on either side of the skinfold, 1 cm below the left thumb and forefinger (i.e. at the level of the selected site).
4. Gradually release the handle to let the jaws of the calipers come to rest on either side of the skinfold.
5. Wait until the needle becomes steady or stops moving fast (3-4 seconds).
6. Take the reading (note that the dial of the calipers reads anti-clockwise).
7. Remove the calipers gently

Always remember to:

- pick up the skinfold gently
- keep the left hand holding the skinfold all the time the calipers are on the subject
- apply the calipers gently
- use the calipers with the right hand with the dial uppermost and horizontal
- pick up and hold the skinfold with your left hand throughout the measurement.

4.1. Triceps skinfold

1. First find and mark the midpoint of the back of the upper arm (using the same method described above for the upper arm circumference).
2. With the subject's arm hanging relaxed at the side of his/her body, pick up the skinfold parallel to the long axis of the arm, clean away from the underlying muscle.
3. Apply the calipers vertically at the marked level.

4.2. Sub-scapular skinfold:

1. Locate the sub-scapular skinfold which is found just below and laterally to the bottom angle of the left scapula (the triangular bone of the shoulder)
2. pick up the fold that runs in a line approximately 45 degrees to the spine along the natural cleavage line of skin .

4.3. Medial calf skinfold:

1. Ask the subject to sit with the knees at 90 degrees.
2. Take a vertical fold on the medial aspect of the left calf at the level of the maximal calf circumference.

5. Blood pressure:

A mercury sphygmomanometer and a stethoscope will be used for measuring the blood pressure.

1. Ask the subject to sit quietly for 5 minutes before blood pressure is measured on the right arm.
2. Use an appropriate cuff size (the cuff should cover 80% to 100% of the student's arm circumference).
3. Ask the student to remove any tight or restrictive clothing from her his right arm and to extend it horizontally on the table.
4. Apply the cuff, making sure that the midpoint is placed over the position of maximal pulsation of the brachial artery.
5. Support the student's arm at heart level with your hand while taking the measurement.
6. First determine the systolic blood pressure by palpation.
7. Place the stethoscope over the brachial artery pulse, proximal and medial to the cubital fossa and below the bottom edge of the cuff.
8. Inflate the cuff approximately 30 mm Hg above the pressure at which the radial pulse disappeared to palpation.
9. Release the pressure in the cuff slowly, at about 2mm Hg/second.
10. Record the pressure obtained at the First Korotkoff sound (point at which sounds returned) as the systolic blood pressure and record the pressure obtained at the Korotkoff phase 5 (disappearance of sounds) as the diastolic blood pressure.
11. Repeat the BP measurement after three minutes.

APPENDIX 7

Food frequency questionnaire of adolescent Bahraini males and females by obese (≥85th) and non-obese (<85th) categories of BMI for age (Model I) N=506 (249 males and 257 females)

Food (times/week)	Males						Females					
	BMI for age percentile				p-value	Odds ratio (95%CI)	BMI for age percentile				p-value	Odds ratio (95%CI)
	Obese (≥85th)		Non-obese (<85th)				Obese (≥85th)		Non-obese (<85th)			
	n	(%)	n	(%)			n	(%)	n	(%)		
Eggs												
$<4^a$	48	(32.4)	100	(67.6)	0.257	1.0*	72	(39.1)	112	(60.9)	0.909	1.0*
$\geq 4^b$	26	(25.7)	75	(74.3)		0.72 (0.41-1.27)	28	(38.4)	45	(61.6)		0.97 (0.55-1.67)
Cheese												
$<4^a$	14	(38.9)	22	(61.1)	0.193	1.0*	23	(44.2)	29	(55.8)	0.378	1.0*
$\geq 4^b$	60	(28.2)	153	(71.8)		0.62 (0.29-1.28)	77	(37.6)	128	(62.4)		0.76 (0.41 -1.40)
Legumes												
$<4^a$	68	(32.1)	144	(67.9)	0.051	1.0*	93	(38.8)	147	(61.3)	0.843	1.0*
$\geq 4^b$	6	(16.2)	31	(83.8)		0.41 (0.16-1.03)	7	(41.2)	10	(58.8)		1.12 (0.41-3.01)
Milk (whole)												
$<4^a$	21	(32.3)	44	(67.7)	0.595	1.0*	48	(45.3)	58	(54.7)	0.079	1.0*
$\geq 4^b$	53	(28.8)	131	(71.2)		0.85 (0.46-1.56)	52	(34.4)	99	(65.6)		0.63 (0.38-1.06)
Beef burger												
$<4^a$	42	(32.8)	86	(67.2)	0.272	1.0*	75	(41.4)	106	(58.6)	0.200	1.0*
$\geq 4^b$	32	(26.4)	89	(73.6)		0.74 (0.43-1.27)	25	(32.9)	51	(67.1)		0.69 (0.39-1.22)
Chicken (fried)												
$<4^a$	59	(31.4)	129	(68.6)	0.313	1.0*	81	(41.3)	115	(58.7)	0.154	1.0*
$\geq 4^b$	15	(24.6)	46	(75.4)		0.71 (0.37-1.38)	19	(31.1)	42	(68.9)		0.64 (0.35-1.18)

* Reference category
a obtained by collapsing "1-3 times a week", "once a month or less"
b obtained by collapsing "more than once a day", "once a day", "4-6 times a week"

(Continued)

	Males						Females					
	BMI for age percentile				p-value	Odds ratio (95%CI)	BMI for age percentile				p-value	Odds ratio (95%CI)
	Obese (≥85th)		Non-obese (<85th)				Obese (≥85th)		Non-obese (<85th)			
	n	(%)	n	(%)			n	(%)	n	(%)		
Pizza												
<4[a]	56	(30.1)	130	(69.9)	0.818	1.0*	74	(38.9)	116	(61.1)	0.984	1.0*
>4[b]	18	(28.6)	45	(71.4)		0.93 (0.49-1.74)	26	(38.8)	41	(61.2)		0.99 (0.56-1.76)
French fries												
<4[a]	39	(33.3)	78	(66.7)	0.240	1.0*	51	(43.6)	66	(56.4)	0.160	1.0*
>4[b]	35	(26.5)	97	(73.5)		0.72 (0.42-1.24)	49	(35.0)	91	(65.0)		0.69 (0.42-1.15)
Salad												
<4[a]	22	(31.0)	49	(69.0)	0.78	1.0*	36	(42.4)	49	(57.6)	0.426	1.0*
>4[b]	52	(29.2)	126	(70.8)		0.92 (0.51-1.67)	64	(37.2)	108	(62.8)		0.81 (0.47-1.37)
Fruits												
<4[a]	12	(26.7)	33	(73.3)	0.621	1.0*	30	(42.9)	40	(57.1)	0.427	1.0*
>4[b]	62	(30.4)	142	(69.6)		1.20 (0.58-2.48)	70	(37.4)	117	(62.6)		0.79 (0.46-1.39)
Fruit Juice												
<4[a]	32	(37.6)	53	(62.4)	0.049	1.0*	40	(40.4)	59	(59.6)	0.697	1.0*
>4[b]	42	(25.6)	122	(74.4)		0.57 (0.31-1.04)	60	(38.0)	98	(62.0)		0.90 (0.52-1.56)
Flavoured drinks												
<4[a]	34	(36.6)	59	(63.4)	0.068	1.0*	35	(37.6)	58	(62.4)	0.752	1.0*
>4[b]	40	(25.6)	116	(74.4)		0.59 (0.34-1.04)	65	(39.6)	99	(60.4)		1.01 (0.645-1.84)

* Reference category
a obtained by collapsing "1-3 times a week", "once a month or less"
b obtained by collapsing "more than once a day", "once a day", "4-6 times a week"

(Continued)

	Males						Females					
	BMI for age percentile				p-value	Odds ratio (95%CI)	BMI for age percentile				p-value	Odds ratio (95%CI)
	Obese (≥85th)		Non-obese (<85th)				Obese (≥85th)		Non-obese (<85th)			
	n	(%)	n	(%)			n	(%)	n	(%)		
Carbonated beverage												
<4[a]	12	(37.5)	20	(62.5)	0.302	1.0*	38	(41.8)	53	(58.2)	0.488	1.0*
>4[b]	62	(28.6)	155	(71.4)		0.67 (0.31-1.45)	62	(37.3)	104	(62.7)		0.83 (0.49-1.40)
Nuts												
<4[a]	50	(30.3)	115	(69.7)	0.777	1.0*	85	(42.1)	117	(57.9)	0.046	1.0*
>4[b]	24	(28.6)	60	(71.4)		0.92 (0.52-1.64)	15	(27.3)	40	(72.7)		0.52 (0.25-1.04)
Puffed corn												
<4[a]	34	(31.8)	73	(68.2)	0.538	1.0*	44	(49.4)	45	(50.6)	0.012	1.0*
>4[b]	40	(28.2)	102	(71.8)		0.84 (0.49-1.45)	56	(33.3)	112	(66.7)		0.51 (0.29-0.89)
Chocolates												
<4[a]	27	(29.0)	66	(71.0)	0.855	1.0*	38	(40.9)	55	(59.1)	0.629	1.0*
>4[b]	47	(30.1)	109	(69.9)		1.05 (0.60-1.85)	62	(37.8)	102	(62.2)		0.88 (0.52-1.48)
Sweets/ candy												
<4[a]	42	(39.3)	65	(60.7)	0.004	1.0*	46	(39.0)	72	(61.0)	0.982	1.0*
>4[b]	32	(22.5)	110	(77.5)		0.45 (0.25-0.78)	54	(38.8)	85	(61.2)		0.99 (0.60-1.64)
Ice cream												
<4[a]	31	(32.0)	66	(68.0)	0.537	1.0*	42	(40.4)	62	(59.6)	0.689	1.0*
>4[b]	43	(28.3)	109	(71.7)		0.84 (0.48-1.46)	58	(37.9)	95	(62.1)		0.90 (0.54-1.50)

* Reference category
a obtained by collapsing "1-3 times a week", "once a month or less"
b obtained by collapsing "more than once a day", "once a day", "4-6 times a week"

LONDON SCHOOL OF HYGIENE
& TROPICAL MEDICINE

ETHICS COMMITTEE

APPROVAL FORM
Application number: 654

Name of Principal Investigator **Aneesa M Al-sendi**

Department **Epidemiology & Population Health**

Head of Department **Professor Betty Kirkwood**

Title **Prevalence and determinants of obesity among adolescents in Bahrain.**

Approval of this study is granted by the Committee.

Chair...
(Professor Harrison Spencer, Dean)

Date ....20/7/00..

Comments from the Committee:

See attached

Approval is dependent on local ethical approval having been received.

Any subsequent changes to the consent form must be re-submitted to the Committee.

Date : 19April 2000

To Whom It May Concern

This is to inform you that the Ministry Of Education has approved the conduction of the research study submitted by the invistigator Ms. Anessa Mohamed AL-Sendi and titled (Prevalence , Determinants of Obesity among Adolescents in Bahrain) on random samples of the primary , elementary and secondary school male and female students .

Wishing you all the best and hoping that the findings of the study will benefit Bahrain .

Thanking you.

Dr. Ebrahim Yousif AL.Abdulla
Assisstant UnderSecretary
Of General and Technical Education

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PAPER

Prevalence of overweight and obesity among Bahraini adolescents: a comparison between three different sets of criteria

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OBJECTIVE: The aim of this study is to determine the prevalence of overweight and obesity among Bahraini adolescents using three different sets of criteria/standards.
DESIGN: Cross-sectional prevalence study.
SETTING: Intermediate and secondary schools in Bahrain.
SUBJECTS: The study included a population-representative sample of 506 Bahraini students (249 male and 257 female) between 12 and 17 y of age. The sample was selected using multistage stratified random sampling technique.
MEASUREMENT: Anthropometric measurements including weight, height and triceps and subscapular skinfolds were taken on the adolescents. Age was verified against school records. To minimize inter-observer error, weight and height were taken by one person while skinfold was taken by two trained persons (one for each sex).
RESULTS: The overall prevalence of obesity among Bahraini boys and girls was high, especially in girls. Obesity was highest (21% in males and 35% in females) when the WHO recommended criteria of BMI for age and skinfolds for age percentiles were applied and lowest (15% in boys and 18% in girls) when the age and sex specific BMI cut-off values of Cole *et al* were used. Compared with those of WHO criteria, estimates of overweight and obesity prevalence obtained with Must *et al* and Cole *et al* were generally close.
CONCLUSIONS: Our data revealed a much higher prevalence rate of obesity in the Bahraini adolescent population than was previously reported, especially among girls. The BMI reference values of Must *et al* and that of Cole *et al* gave relatively similar estimates and appear to be more practical for use in surveys aimed at estimating the prevalence of overweight and obesity among adolescents than the WHO recommended composite criteria.
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Keywords: body mass index; adolescents; overweight; obesity

Introduction

Childhood and adolescent obesity is a public health problem of increasing concern both in the developed countries and in countries undergoing cultural and economic transition. Data from the Arab Gulf Countries, including Bahrain, indicate an increase in the prevalence of overweight and obesity among the adolescent population (Eid *et al*, 1986; Musaiger *et al*, 1993a,b; Al-Nuaim *et al*, 1996). In Bahrain, several studies were carried out to estimate obesity in school children. These studies have relied on the weight for height tables, skinfold measurement or body mass index (BMI) criteria to determine overweight and obesity (Amine, 1980; Blair & Gregory, 1985; Musaiger *et al*, 1993a,b). However, none of these studies used the recently proposed measurement of obesity by WHO (1995) and Cole *et al* (2000).

Several criteria and various standards have been proposed to assess obesity in children and adolescents. One of the commonly used standard is that developed by Must *et al*

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(1991) which are based on data from the US (NHANES I) surveys. The 85th and 95th percentiles of BMI have been suggested to define overweight and obesity in the adolescent (Himes & Dietz, 1994). The World Health Organization Expert Committee has recommended the use of both the BMI-for-age and the skinfold-for-age as the best indicators for the assessment for obesity in adolescents (WHO, 1995). The WHO has also recommended the use of Must *et al* reference data when the local reference is not available. More recently, Cole *et al* (2000) have proposed age- and sex-specific BMI cut-off points for overweight and obesity in children which are linked to the adult obesity cut-offs of 25 and 30 kg/m^2 and based on pooled international data. Different criteria were used by many European researchers, as 85th and 97th percentiles were used to define overweight and obese individuals based on gender-age-specific BMI (Rolland-Cachera *et al*, 2001).

Criteria for overweight and obesity vary in their applicability between different countries and across age groups and there is a need to determine which is the most appropriate standard or cut-off to use in assessing the degree of obesity in any population. The purpose of this study, therefore, is to determine the prevalence of obesity and overweight in Bahraini adolescents using three different sets of criteria/standards, namely those developed by Must *et al* (1991), the composite criteria of BMI for age and skinfold for age recommended by the WHO Expert Committee (WHO, 1995) and the recently published standards of Cole *et al* (2000).

Subjects and method

The study population was Bahraini male and female intermediate and secondary school students aged 12–17 y. A population-representative sample of 506 students (249 males and 257 females) was selected using multi-stage stratified random sampling technique. The study was conducted between September and November 2000. The sample was selected from different educational grades within the elementary and secondary school levels and different geographic areas of Bahrain to ensure that the appropriate age groups and different strata of the target population are represented. Bahrain was first divided into its four governorates, and all the intermediate and secondary schools in each governorate were numbered and then a proportional sample of four or eight schools were randomly chosen from each governorate. After multistage sampling 25 schools, a systematic random sample was selected to substitute the non-Bahraini in each educational level. Students' reported age and date of birth were verified against the school's records, which in turn were based on the students' birth certificates. Of the total sample, 506 students were included, and 34 students (6.7%) were excluded because of missing one or more data.

Anthropometric measurements including weight, height, triceps and subscapular skinfold thickness were taken on the adolescents and according to the method described by Fidanza (1991). Weight and height measurements were taken by a single person, while the skinfold thickness measurements were carried out by two skilled persons, one for each sex.

Data were analysed to determine overweight and obesity rates, using the NHANES I reference data for BMI for age (Must *et al*, 1991), the age- and sex-specific BMI cut-off points reported by Cole *et al* (2000) and World Health Organization criteria of BMI-for-age and skinfold-for-age (WHO, 1995).

Overweight and obesity status were determined by using the following criteria:

1. Using the age and sex specific BMI reference data of Must *et al* (1991) — overweight, 85th to 95th percentile; obese, ≥ 95th percentile.
2. Using the BMI cut-off values of Cole *et al* (2000) — these are sex- and age-specific BMI cut-off points consistent with the internationally accepted cut-off points for adults overweight and obesity (ie BMI of 25 and 30, respectively).
3. Using the WHO expert committee composite criteria of BMI-for-age and skinfold-for-age (WHO, 1995) (based on Must *et al*, 1991) — overweight, BMI ≥ 85th to 94th percentile *plus* < 90th percentile of both the triceps and subscapular skinfold for age; obese, BMI ≥ 85th percentile *plus* ≥ 90th percentile of both the triceps and sub-scpaular skinfold for age.

Results

Mean standard deviation and median of BMI for male and female Bahrain adolescents are presented in Table 1. As age increased the mean BMI increased. However at all ages females have greater BMI than males

The prevalences of overweight and obesity estimated using three different sets of criteria for the Bahraini boys and girls are shown in Table 2. The overall prevalence of obesity is relatively high, especially in females. Based on the WHO recommended criteria (WHO, 1995), about 21% of the males and 35% of the females were obese. The highest percentage of obesity in boys occurred at age 14 y (29%) and in girls occurred at age 16 y (42.5%). Overweight was more than twice (8%) as prevalent in boys as in girls (3.5%). Rates of overweight and obesity showed no specific pattern of variations with age, in both sexes.

When Must *et al* (1991) reference values for overweight were applied, an overall prevalence of overweight, which was higher than that obtained with the WHO criteria, ranging from 17% in boys to 20% in girls.

Relative to the Must *et al* (1991) indicator, Cole *et al* (2000) cut-offs gave slightly lower estimates of obesity prevalence, suggesting that age-specific BMI cut-off points were more stringent in identifying obese cases than the BMI centile-based standard. Nearly 15% of the boys and 18% of the girls were obese. In contrast, overall rates of overweight were higher than those obtained by Must *et al* (1991) standard and ranged from 15% in males to 24.5% in females.

Table 1 Mean, standard deviation and median of BMI for male and female Bahraini adolescents

Age (y)	n	Mean BMI	± s.d.	Median
Male				
12	41	18.5	4.0	17.0
13	46	21.2	5.6	19.8
14	48	22.3	5.8	21.0
15	37	21.0	4.9	19.2
16	43	22.5	5.3	21.2
17	34	24.4	7.1	22.1
Female				
12	50	21.5	6.0	20.5
13	43	21.8	4.4	21.3
14	40	22.0	5.0	20.9
15	41	24.7	7.0	23.3
16	40	25.3	7.7	23.7
17	43	25.0	7.0	23.4

In general, estimates of the prevalence of overweight and obesity obtained with Must *et al* (1991) and Cole *et al* (2000) were generally close. The proportions of obese categorized on the basis of these two criteria were identical at age 12, 15, 16 and 17 y in boys and at age 14 and 17 y in girls. Both criteria showed that obesity was most frequent at age 14 y in boys and at age 15 y in girls.

Discussion

Despite the different estimates obtained by the three sets of criteria used, out findings indicate a high prevalence of overweight and obesity among adolescents in Bahrain. The trend in obesity among the females studied was very similar to the data reported by Musaiger *et al* (2000), which were collected in 1992. However, our findings showed a remarkable decline in overweight and an increase in obesity using the same reference data (Must *et al*, 1991). The prevalence of overweight for the same reference data (Must *et al*, 1991). The prevalence of overweight for the same age group (12–17 y) was 36.5% in 1992 and declined to 18.7% in our study, whereas that of obesity was 7% and increased to 20.2%. These observations suggest a trend of greater fat accumulation in adolescent girls during the 1992–2000 period. In boys, obesity level was also higher than that reported previously (Amine, 1980; Musaiger *et al*, 1993a,b) and appeared to be strongly influenced by the higher percentage of obesity among the 14-y-old males (29.2%). The observation that the highest proportion of obesity among girls occurred at age 16 y was in agreement with previous report (Musaiger *et al*, 2000).

In both sexes and at almost all ages, the WHO composite criteria gave lower estimates of overweight but higher estimates of obesity prevalence than the indicators of either Must *et al* (1991) or Cole *et al* (2000). This appears to be related to the fact that, according to the WHO recommended criteria, overweight is defined on the basis of the BMI (≥85th BMI percentile) while obesity is defined on the basis of both BMI (≥85th BMI percentile) and skinfold (≥90th percentile of triceps and ≥90th percentile of subscapular skinfold). As a result, when these cut-offs were applied to the data set, participants with BMI values at or above the 85th percentile and with high subcutaneous fat were shifted from the overweight category to the obese

Table 2 Prevalence (%) of overweight and obesity among male and female Bahraini adolescents using three reference data

Weight status	Reference data	Age (y) 12	13	14	15	16	17	Total
Males		(n=41)	(n=46)	(n=48)	(n=37)	(n=43)	(n=34)	(n=249)
Overweight	WHO (1995)	7.3	8.7	8.3	5.4	9.3	11.8	8.4
	Must et al (1991)	19.5	10.9	12.5	8.1	9.3	20.6	13.3
	Cole et al (2000)	19.5	15.2	16.7	8.1	9.3	23.5	15.3
Obese	WHO (1995)	17.1	23.9	29.2	13.5	18.6	23.5	21.3
	Must et al (1991)	4.9	21.7	25.0	10.8	18.6	14.7	16.5
	Cole et al (2000)	4.9	17.4	20.8	10.8	18.6	14.7	14.9
Females		(n=50)	(n=43)	(n=40)	(n=41)	(n=40)	(n=43)	(n=257)
Overweight	WHO (1995)	4.0	2.3	5.0	7.3	0.0	2.3	3.5
	Must et al (1991)	22.0	20.9	15.0	17.1	20.0	16.3	18.7
	Cole et al (2000)	28.0	27.9	22.5	22.0	25.0	20.9	24.5
Obese	WHO (1995)	38.0	32.6	22.5	39.0	42.5	37.2	35.4
	Must et al (1991)	20.0	14.0	12.5	29.3	22.5	23.3	20.2
	Cole et al (2000)	16.0	11.6	12.5	24.4	20.0	23.3	17.0

category, resulting in lower estimates of overweight and higher estimates of obesity than those determined by other standards such as those of Must *et al* (1991) and Cole *et al* (2000). Recently, Flegal *et al* (2001) compared the prevalence of overweight in US children calculated with Cole *et al* and Must *et al* standards and found that Cole *et al*'s standards produced higher estimates of overweight and obesity in adolescents than the standard of Must *et al*. In this study we found a similar trend for the estimate of overweight prevalence but not for that of obesity.

Sexual maturation is an important factor influencing BMI and body composition (Daniels *et al*, 1997; Bini *et al*, 2000). In the present study however, pubertal staging was not performed due to some cultural constraints. A previous work in which puberty was determined indirectly (by questioning girls about age of menarche and attainment of adult voice in boys) have found that the mean age of puberty in Bahraini boys was 14.6 y and that of menarche in girls was 13.0 y (Musaiger *et al*, 1993a,b).

The high prevalence of obesity documented in this study has important public health implications given the recent evidence linking childhood and adolescent obesity and increased risk of obesity and morbidity in adulthood (Must & Strauss, 1999). The health statistics in Bahrain indicate that obesity-related chronic diseases such as heart disease, diabetes and hypertension are the main public health problems and represented more than 35% of total deaths (Ministry of Health, 2000). Therefore any programme to reduce the occurrence of obesity among adolescents will have a great impact.

Although BMI is not an exact measure of body fat, BMI for age-based standards such as that of Must *et al* or Cole *et al* appear to be more preferable to use than the WHO criteria (which are based on both BMI and skinfold). Skinfold thickness measurements are subject to considerable inter- and intra-user error, whereas measures based on height and weight are simple to obtain in wide variety of settings and reliable (Himes, 1989). this is particularly relevant to developing countries, where people highly skilled in skinfold measurement are scarce. The high subcutaneous fat in adolescents suggested by the high percentage of obese boys and girls identified using the composite BMI and skinfold criteria (ie WHO recommended criteria) is a cause of concern since it is known that the reliability of skinfold measurement decreases as body fat increases. Furthermore, the use of a BMI reference such as that of Must *et al* or Cole *et al* would allow ease of comparison with corresponding studies from other countries in the world.

References

Al-Nuaim AR, Bamgboye EA & Al Herbish A (1996): The pattern of growth in Saudi Arabian male school children. *Int. J. Obes Relat. Metab. Disord.* 20,1000–1005.

Amine EK (1980): *Bahrain Nutrition Status Survey*. Abu-Dubi: UNICEF, Gulf Area Office.

Bini V, Celi F, Berioli MG, Bacosi ML, Stella P, Giglio P, Tosti L & Falorni A (2000): Body mass index in children and adolescents according to age and pubertal stage. *Eur J. Clin. Nutr.* 54, 214–218.

Blair D & Gregory WB (1985): *The Nutrition Status of Bahraini Girls aged 7–18 years*. Bahrain: Bahrain Sport Institute.

Cole TJ, Bellizzi MC & Flegal KM (2000): Establishing standard definition for child overweight and obesity worldwide: International survey. *Br. Med. J.* 320, 1240–1243.

Daniels SR, Khoury PR & Morrison JA (1997): The utility of body mass index as a measure of body fatness in children and adolescents: differences by race and gender. *Pediatric* 99, 804–807.

Eid N, Al-Hotti S, Bourishly N & Khalafawi M (1986): Nutritional anthropometry of school children in Kuwait. *Nutr. Report Int.* 33, 253–260.

Fidanza F (1991): *Nutritional Assessment: a Manual for Population Studies*, ed. F Fidanza. London: Chapman & Hall.

Flegal KM, Ogden CL, Wei R, Kuczmarski RL & Johnson CL (2001): Prevalence of overweight in US children: comparison of US growth charts from the Centers for Disease Control and Prevention with other reference values for body mass index. *Am. J. Clin. Nutr.* 73, 1086–1093.

Himes JH (1989): Reliability of anthropometric methods and replicate measurements. *Am. J. Anthropol.* 79, 77–80.

Himes JH & Dietz WH (1994): Guidelines for overweight in adolescent preventative services: recommendations from and expert committee. *Am. J. Clin. Nutr.* 59, 307–316.

Ministry of Health (2000): *Health Statistics*. Bahrain, Manama.

Musaiger AO, Matter AM, Alekri SA & Mahdi A (1993a): Obesity among secondary school students in Bahrain. *Nutr. Health* 9, 25–32.

Musaiger AO, Matter AM, Alekri SA & Mahdi A (1993b): Obesity among secondary school students in Bahrain. *Nutr. Health* 9, 25–32.

Musaiger AO, Al-Ansari M & Al-Mannai M (2000): Anthropometry of adolescent girls in Bahrain, including body fat distribution. *Ann. Hum. Biol.* 27, 507–515.

Must A & Strauss RS (1999): Risks and consequences of childhood and adolescent obesity. *Int. J. Obes. Relat. Metab. Disord.* 23(Suppl 2), S2–S11.

Must A, Dallal GE & Dietz WH (1991): Reference data for obesity: 85th and 95th percentile body mass index (wt/ht2) and triceps skinfold thickness. *Am. J. Clin. Nutr.* 53, 839–846.

Rolland-Cachera MF, Deheger M & Bellisle F (2001): Definition actuelle et evolution de la frequence de l'obesite' chez l'enfant. *Cah. Nutr. Diet.* 36, 108–112.

WHO (1995): *Physical status: the use and interpretation of anthropometry*. WHO Technical Report Series no. 854, p 271. Geneva: World Health Organization.