NUTRITIONAL FACTORS ASSOCIATED WITH OBESITY IN ADOLESCENT FEMALES IN THE UNITED ARAB EMIRATES

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DEDICATION

I dedicate this thesis to

The memory of the person who
guided me through life,
gave me strength, trust and support -
My beloved father (God bless his soul).

The person whose unconditional love
gave me encouragement and
confidence to achieve my goal in life -
My beloved mother.

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ABSTRACT

The prevalence of overweight and obesity in children and adolescents is increasing rapidly in developed and developing countries. This study was conducted in the United Arab Emirates (UAE) to ascertain the extent and the nature of this problem.

The UAE has undergone a rapid change in socio-economic status. This change has affected many aspects of life in the UAE. The prevalence of overweight and obesity and the contributing factors were investigated in a sample of (n=898) young children and adolescent females in the UAE.

The prevalence of overweight was the highest at age 10 years (30%) and lowest at age 17 years (7%). The prevalence of obesity was the highest at age 11 years (15%) and the lowest at age 13 and 15 years (6%).

Food intake and food habits have also been influenced by the rapid change in socio-economic status. Traditional foods have been replaced by new foods. Snack foods of high energy density and the consumption of greater energy intake at weekends compared to schooldays was a consistent observation. The study also showed that the adolescent females were engaged in low levels of physical activity and most of their activities were limited to sleeping and sitting activities.

The possible explanation of the high prevalence of overweight and obesity among adolescent females may be attributable to the high dependence on the housemaids, consumption of high energy density foods and the difficulties in undertaking physical exercise due to cultural and weather conditions.

An examination of energy intake, basal metabolic rate and energy balance in a group of seven women in UK was shown to be influenced by the phases of the menstrual cycle. The wide intra-individual variability in basal metabolic rate during the menstrual cycle may explain why women may be more prone than men to become obese.

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ABBREVIATIONS

A	Age
AA	African American
AEA	Average Energy Allowances
BEE	Basal Energy Expenditure
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index/Quetelet's index
BMR	Basal Metabolic Rate
CDC	Centres for Disease Control and Prevention
CO_2	Carbon Dioxide
CT	Computed Tomography
CV	Coefficient of Variation
CVD	Cardiovascular Diseases
DLW	Doubly Labelled Water
DM	Diabetes Mellitus
DRV	Dietary Reference Values
DXA	Dual Energy X-ray Absorptiometry
EAR	Estimated Average Requirement
EB	Energy Balance
EE	Energy Expenditure
EI	Energy Intake
FAO	Food and Agriculture Organization
FFM	Fat Free Mass
FFQ	Food Frequency Questionnaire
FM	Fat Mass
FSH	Follicle Stimulating Hormone
GnRH	Gonadotropin Releasing Hormone
H	Height
H_2	Hydrogen
HDL	High Density Lipoprotein Cholesterol
HMR	Heart Rate Monitoring
HR	Heart Rate
HW	Hydrostatic Weighing

IOTF	International Obesity Task Force
IRA	Infra Red Analysis
kcal	Kilocalorie
kJ	Kilo Joule
LCD	Low Caloric Diet
LDL	Low Density Lipoprotein Cholesterol
LH	Lutenizing Hormone
LRNI	Lower Reference Nutrient Intake
mg/dl	Milligram per decilitre
MJ	Mega Joule
MLIC	Metropolitan Life Insurance Company
MRI	Magnetic Resonance Imaging
MUAC	Mid Upper Arm Circumference
MUAMC	Mid Upper Arm Muscle Circumference
NAA	Neutron Activation Analysis
NCHS	National Centres for Health Statistics
NHANES	National Health and Nutrition Examination Survey
NIDDM	Non Insulin Dependant Diabetes Mellitus
O_2	Oxygen
OA	Osteoarthritis
OGTT	Oral Glucose Tolerance Test
OSA	Obstructive Sleep Apnoea
PAL	Physical Activity Level
PAR	Physical Activity Ratio
PCOS	Poly Cystic Ovarian Syndrome
PPT	Post-Prandial Thermogenesis
R^2	Coefficient of Determination
RNI	Reference Nutrient Intake
RQ	Respiratory Quotient
SD	Standard Deviation
SNS	Sympathetic Nervous System
SPSS	Statistical Package for Social Sciences
T.G	Triglycerides
TBP	Total Body Potassium

TBW	Total Body Water
TEE	Total Energy Expenditure
TOBEC	Total Body Electrical Conductivity
TSF	Triceps Skinfold Thickness
UAE	United Arab Emirates
UCE	Urinary Creatinine Excretion
UK	United Kingdom
UN	United Nations
UNU	United Nation University
USA	United States of America
VLCD	Very Low Caloric Diet
W	Weight
WHO	World Health Organisation
WHR	Waist Hip Ratio

CHAPTER ONE: STUDY SITE: UNITED ARAB EMIRATES

The United Arab Emirates (UAE) is a federation born on the second of December 1972. This federation consists of seven Emirates which are: Abu Dhabi, Dubai, Al Sharjah, Ajman, Umm El Quwain, Ras Al Khaimah and Al Fujairah.

1.1. Geography

UAE lies between latitudes 22-26.5 degrees North and longitudes 51-56.5 East and is bordered to the north by the Arabian Gulf, to the east by the Gulf of Oman and Sultanate of Oman, to the south by Sultanate of Oman and Saudi Arabia, and to the west by Qatar and Saudi Arabia (Figure 1.1).

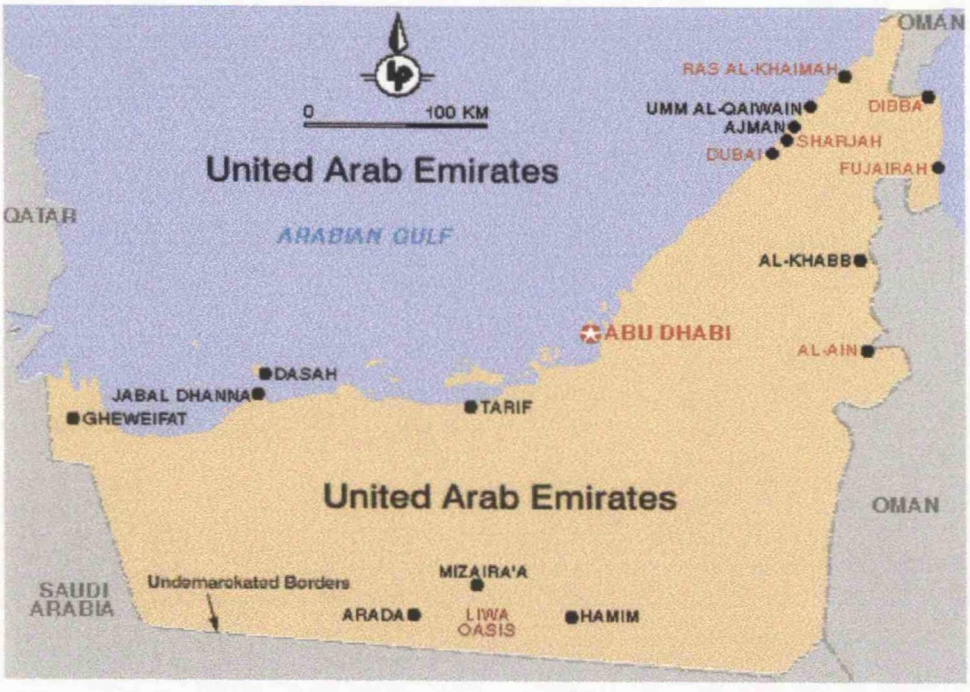

Figure 1.1: Borders of the UAE. Source: United Nations Development programme (2001).

UAE has an area of 77,700 square kilometres, excluding the islands, of which 65% is desert. The areas of UAE by Emirate are shown in Table 1.1.

Table 1.1: The area of the UAE by Emirate

Emirate	Sq.Kilometre	Percentage
Abu Dhabi	67340	86.7
Dubai	3885	5.0
Al Sharjah	2950	3.3
Ajman	259	0.3
Umm El Quwain	777	1.0
Ras Al Khaimah	1683.5	2.2
Al Fujairah	1165.5	1.5

1.2. Climate

With the Tropic of Cancer crossing its southern part, the UAE is an arid, tropical country with two distinct seasons: hot summer between April and September (temperature exceeds 50°C and 99% humidity) and a mild winter between October and March. During winter the days are sunny (the average temperature ranges between 20-25°C) and the nights are cold (average temperature 15°C). The rainfall is generally scarce: 107 mm annually, which falls between the months of November and April. The potential yearly evaporation is over 3000 mm.

1.3. Demographic Distribution

The population in UAE is divided into two groups, locals and non-locals (expatriates). The vast increase in wealth has had a major impact on the demographic structure with the original, relatively small population (1968 census carried out by Britain recorded a population of 180,000), expanding rapidly, mainly due to an influx of expatriate workers.

The nationality of the expatriates who come to UAE can be divided into three groups (1) an Arab group including Palestinian, Jordanian, Egyptian, Yemenis, Syrians, and Lebanese; (2) an Asian group, including Pakistanis, Indians, and Iranians, which is the largest group; and (3) a Western group including citizens from United States of America (USA) and United Kingdom (UK).

The first census, carried out in 1975, recorded a population of 557,887. The average annual growth rate has decreased from 13% between 1975-1985 to 6% between 1985-1995. However if this average remains at the current level, the

population will double in about 12.5 years' time.

An official analysis of the 1995 Census concluded that the population of UAE in 1995 was 2.41 million, an increase of one million between 1985-1995, with an average increase of 100,000 people annually (United Arab Emirates, Ministry of Planning, 1997). Figure 2 shows the population pyramid of the last census (1995). As a result of the UAE's reliance on expatriate manpower, there has been a steady decline in the proportion of UAE citizens in the total population over the course of the past 30 years. In 1968, 64% of the population were nationals of the seven Emirates and 37% were expatriates. By 1975 the percentage had altered to 30% nationals and 70% expatriates (oil boom era), while succeeding years have shown a further decline in the percentage of nationals as the population has continued to grow. The population estimates for 1997 were 2.64 million, of which 1.54 million were non-nationals.

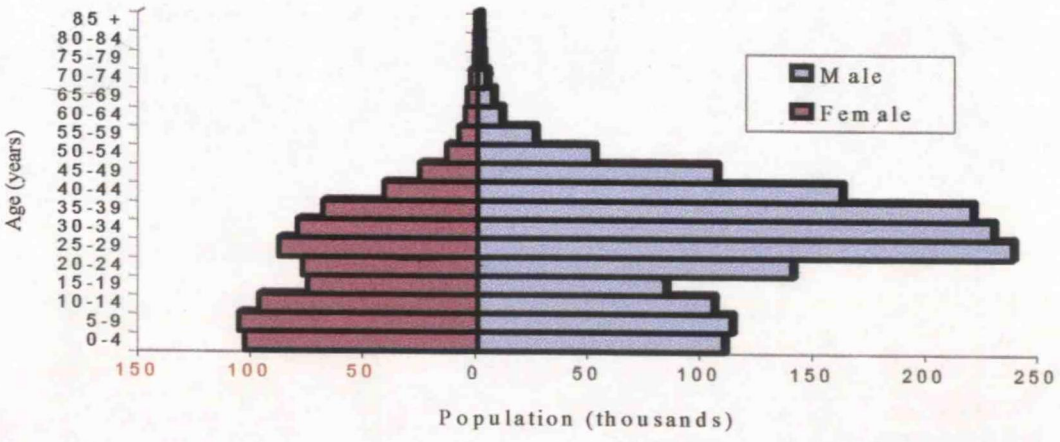

Figure 1.2: Population pyramid, by age groups, sex (United Arab Emirates, Ministry of Planning, 1997)

The distribution of people by Emirates according to the 1995 Census is shown in Table 1.2.

Table 1.2: Distribution of people by Emirates

Emirate	% Population
Abu Dhabi	39
Dubai	29
Al Sharjah	17
Ajman	5
Umm El Quwain	2
Ras Al Khaimah	6
Al Fujairah	3

One third of the population are resident in Abu Dhabi, a justification for choosing this site for the present study.

1.4. History

The local population of the present day UAE is tribal in origin. Most national householders can quote a tribal name which rightfully forms part of their own name and is used as the last part of a name after their father's name.

The recorded history of UAE is relatively short. People have been living in a settled community on the Peninsula for at least 7000 years. Before union, from the mid 1950's onwards, the Emirates were known as the Trucial States and were under a system in which each of the individual Emirates had separate treaty agreements with the British colonial administration. Each state was ruled by a Sheikh, traditionally the leader of the most powerful tribe (Heard – bey, 1982).

1.5. Culture

1.5.1. Religion

People of the UAE embrace Islam and, like other Islamic countries, are called Muslims. Traditionally, the UAE belonged to the Sunni Muslim branch of Islam, which was also practiced in Saudi Arabia. Islam is the state religion and its Muslim identity is perhaps the most important unifying aspect of the UAE culture.

There are five pillars to Islam. The first is accepting the faith and believing in Islam. The second is praying five times a day. The third is fasting during the holy

month of Ramadan. During this month, Muslims fast from sunrise until sunset. The beginning of this month depends on the moon. During Ramadan, Muslims must abstain from eating, drinking and smoking during the daylight hours. They eat two meals, the first called *Sahour*, which starts before sunrise and consists of bread, cheese, eggs, fruits and tea, and the second meal called *Iftar*, which starts after sunset and consists of soup, meat, rice, vegetables and sweets. The fourth pillar of Islam is paying *Za-kkah* (paying alms to the poor). The fifth and the extreme importance to any Muslim is the pilgrimage to Mecca to perform Hajj. This should be performed at least once in a Muslim's life.

In the Islamic religion, Friday is considered the holiest day of the week and thus it is a holiday in Muslims countries, including the UAE.

1.5.2. Food Habits

The rapid economic growth of the UAE affects the life-style of the people, including their food consumption patterns. Traditional foods, like dates, milk, rice and fish, have been replaced by other foods from different regions. Despite the changes in food consumption patterns, the traditional dishes are still found in their meals. Traditional cooking methods are still used in preparing these dishes, which are (Al-Ansari, 1994):

1. *Tannur*: A clay oven built in the earth; the pot is covered with an iron lid. This method is suitable for cooking meat.
2. *Kuar*: Like the hearth, either round or square in design, small or large, used for boiling coffee and tea; the pots are then left to keep warm.
3. *Alaa Thouu*: A piece of metal warmed by direct heat from the fire. This method is used to prepare different types of bread.
4. *Alaa-gas*: A regular gas stove which has found its way into the modern Arabic kitchen.

As most traditional Arab homes have both an inside and outside kitchen, the traditional cooking methods are still used today, particularly for dishes which demand more authentic methods.

As in any other Arabic country, the UAE population eat three main meals daily with a fourth meal called *Fou-alla*, eaten as a snack. Each meal is described below.

1.5.2.1 Breakfast (Re-u-que) 5:00-10:00 am

This meal starts any time after morning prayers and is usually eaten in the kitchen or the sitting room (called *Salah*). It normally consists of tea, coffee, fruit juice, cheese, jam, fresh honey and eggs cooked in various ways, in addition to some traditional types of bread. For example:

1. *Rgag*: An unleavened bread that is prepared at home (Figure 1.3). Flour is mixed with salt and water until a loose elastic dough consistency is formed. A handful of dough is then spread in a very thin layer, by hand, on the top of an iron lid (*Alaa-Thouu*). When the edges of the dough start drying and lifting from the pan surface, the bread is removed with a knife and folded in half or quarters (Musaiger, 1993). Each loaf weighs 30 grams (i.e. one serving of bread).

Figure 1.3: *Rgag* bread. Source: UAE Forever (2000c)

2. *Khameer*: A leavened bread consisting of flour, yeast, eggs, and some spices, for example ground fennel (Figure 1.4), saffron and cardamom. The bread must be left for at least 12 hours before baking. The bread is baked in an ungreased small frying pan; a handful of dough is placed in the pan and flattened. When the bread begins to swell and turns brown on the bottom it is turned on to the other side. Each loaf weighs approximately 60 grams.

Figure 1.4: *Khameer* bread. Source: UAE Forever (2000b)

3. *Cho-bab*: This bread is like the American crepe. It is similar to *Khameer* except that more water is added and the bread is left for 2-3 hours before baking.

Besides the different types of bread, there is a traditional dish called *Ba-la-leeth*, a sweet vermicelli. An omelette is prepared by frying vermicelli in oil and then cooking in water, with sugar; finally fried eggs are placed on top.

1.5.2.2. Lunch (Gu-daa) 1:30-3:30 pm.

This is the most important meal of the day, particularly for men. Traditionally, rice is the main dish and should be prepared daily, although this may be by different methods such as boiling or steaming. In the past, the diet in the UAE depended on the geographic location of the people: those who lived near the sea ate from the sea (fish); those who lived inland depended on their camels and goats. Being an arid desert climate, vegetables were rarely used in the diet. Gradually this diet has changed and vegetables have become more easily available through growing and importing. Meat is an essential item in addition to fish. Dates, in any form, are also served during this meal as well as during the whole day. *Laban* (buttermilk) accompanies this meal.

Nowadays, this meal consists of meat, whether it is lamb, goat, chicken or fish. Rice is still an essential dish in addition to mixed cooked vegetables called *Salonah* with tomato paste and any dairy product such as yoghurt or buttermilk.

Unfortunately, most of the children and adolescents nowadays replace this meal with fast foods, such as beefburger, fried chicken, and French fries (section 6.1.3).

1.5.2.3. Dinner (Aa-sha)

This is a simple meal, consisting of bread with soup and some cheese; rice is rarely served during this meal. There is no definite time for this meal.

1.5.2.4. *Fou-alla*

Fou-alla is a large round tray filled with traditional foods, usually sweets, and is served after dinner with tea and coffee. Fruits can also be offered. The family and their guests sit around the tray and, first a bowl of water is offered to wash the fingertips of the right hand (eating with hands is still a common practice in UAE homes, knives and forks are used in restaurants) to eat sweets. A tray of tea and coffee cups are found with a bowl, half filled with water, for washing the cups of coffee.

Once every one has eaten from the tray and drunk their coffee or tea, indicating that they are full, it is the host's duty to insist that their guest has not eaten a thing and therefore will keep offering more food!

For the women, the perfume ceremony begins. A box filled with six to eight bottles of various local perfumes and oils (musk oil, aloewood (*Oud*), saffron oil) is offered. An incense burner (*Mad-kan*) is also filled with burning charcoal and pieces of aloewood or incense are scattered over it. When the aromatic charcoal starts to smoke, the hostess passes it to the first guest in the circle who accepts with her right hand, lifts her facemask, and keeps it until satisfied with the aroma.

1.5.2.5. Dates

Dates are the main food item that is essential in the whole day. The *Phoenix dactylifera* (the date palm) is the only tree that can grow in a sandy desert where water never flows. It can tolerate very high salinity and intense heat. The first harvest is usually around five years later. In the UAE there are 35 million date palm trees and date production was 388,190 tons in 1997 (Agriculture and Fisheries, 2001).

Harvest of the dates takes place during the hottest period of the year, between June and October, depending on the type of date tree. The harvest involves climbing the tree and cutting the heavy branches (Figure 1.5).

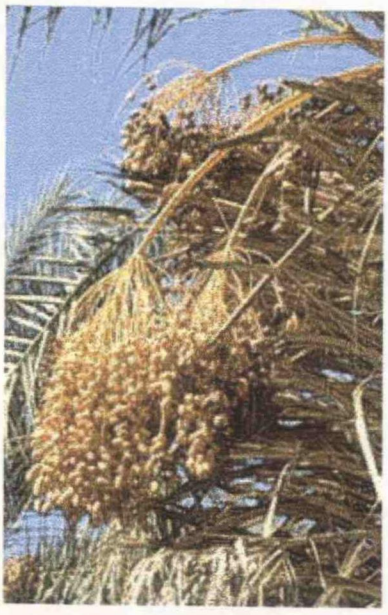

Figure 1.5: Date branch. Source: University of California (2001)

People in the UAE like to eat dates fresh when only half of the fruit is soft and brown, called *Rutab*. The dried dates, called *Tamer,* can be kept almost indefinitely because of their high sugar content. They can be stored and taken on journeys through the desert, into mountains or out to the sea. They are also offered daily along with Gulf coffee (Figure 1.6).

1.5.2.6. Coffee

Coffee is the second important food item. No meal would be complete without coffee. *Quahwah* is served in the traditional style coffee pot known as *Dallah*. This tradition remains and visitors to the UAE should bear in mind that to refuse a cup of coffee from a local host is considered quite rude, sometimes you may share with the host 2-3 small cups of coffee. The local coffee is quite light, unsweetened and flavoured with cardamom and saffron, making it sweet and aromatic.

Figure 1.6: *Quahwa*. Source: UAE Forever (2000a)

Traditionally, coffee beans are roasted in a frying pan over a direct heat and then ground by a pestle and mortar. However' nowadays coffee can be bought roasted and ground from the markets. The coffee is boiled with water; a mixture of cardamom and saffron are added to produce the flavour of Gulf coffee.

The coffee is poured into a special coffee pot, *Dallah* (traditional pot made of copper and kept on a kuar to keep it warm), although nowadays a special pot (thermos) which will keep the coffee warm is available.

Coffee is served in the traditional way, the pot of coffee should be held in the left hand of the host, the cups in the right hand and a small amount, around 15 mm, is poured .The local method of indicating that one has had enough coffee is to shake the cup a little from side to side.

1.5.3. Camel rearing

Camel rearing is another part of the UAE culture. This is considered God's gift to the Bedouin. This animal gives the local tribesman his mobility and has been central to life in the UAE for thousands of years. The camel provides milk, meat and leather, while its shoulder-blades were used as little blackboards for children studying.

Nowadays, good highways between the Emirates and advanced technology means that school equipment is readily available, but many local families still own a few camels for meat and milk.

1.5.4. Clothing

The local people in the UAE have their own distinctive dress. The national dress for women is the A*baya* (black cloak), a black full length covering. Under the

Abaya women wear loose *Sirwal* or trousers and a dress called *Kandura*, coloured embroidered in gold or silver threads. The *Burga* (face mask) covers the nose and mouth. Finally, the head-clothes *Shayla* (veil) is also black, but nowadays it may be worn in different colours. The older women mainly wear the traditional clothing; it is less common among school-age children or female university students.

For men, the national dress is a white full-length shirt *Dishdash*, the head cloth *Gutra,* usually red-checkered or plain white, and the black rope wrapped around the head to keep the *Gutra* in place, *Agal*. On some occasions, for example wedding ceremonies, men wear *Abba or Bisht* (a thin gown) outside the *Dishdash*; these are usually black or brown in colour.

1.6. Recent Evolution

1.6.1. Pre-oil era

Before the discovery of oil, the population of this country was very small. The majority of people were nomads and very few were educated. The people survived on trade, pearl diving and also businesses in spices and other jewels. Poverty was a part of every day life; the family would survive on fishing, rearing camels or goats and small-scale cultivation of crops, including dates. Food sources were limited to what could be obtained from their environment, for example fish, camel milk and dates (Musaiger 1987).

1.6.2. Oil discovery period

Oil, in commercial quantities, was only discovered in the late 1950's. During the oil discovery period, there was gradual change in economic development. Many workers left agriculture, pearl diving and fishing and enrolled in the oil industry for a better paid job.

In 1970-1980, the oil boom period, a rapid change in the socio-economic status was seen. There was an impressive change in all aspects of life: the mud, palm-leaf and stone houses were replaced by concrete ones; streets became asphalt streets; electricity and safe water supply were supplied; television, car and modern household facilities had became available in most of the houses.

The population had moved from a simple Bedouin tribe unsettled society to a commercial modern business society. This vast change is characterized by negative and positive effects. The negative effects include: (1) high dependence on housemaids

in home management, even child rearing; (2) dependence on processed foods which have replaced traditional foods; (3) decrease in mobility because the houses are well equipped. The positive effects include (1) decrease in illiteracy; (2) development of health services; (3) development of infrastructure; (4) higher quality of life for most people.

1.7. Education

In earlier days, most families required the help of the growing children in the household, in date gardens, on fishing boats and with the domestic animals and few would have been able to afford to pay for formal education.

Some families considered it to be important that one should be able to read the Koran (The Muslim Holy Book) and therefore they sent their children to learn reading and writing and reciting the Koran. Mutawwa would gather a number of boys and girls in a kuttab, a Koranic school, which could be in his house or anywhere convenient, even under a tree. A child was often considered to have completed his education only when he could recite the entire Koran.

In 1971 when the federation was formed, only a tiny minority of children had access to formal schooling and the majority of these were boys. The number of state schools has risen from 132 in 1972 to 668 in 1997-98 and student numbers attending Government schools have increased from 40,115 to 312,000 in the same period. The most important development here is the comprehensive free education system which extends equally to both sexes.

The number of schools in 1996/1997 was 273, 288 and 81 respectively for females, males and mixed education. The number of female students (241,951) and male students (254,333), divided depending on the stage of education, are shown in Table 1.3.

Table 1.3: Total number of school age students in different stages

Stage	Male	Female
Primary	76,246	75,037
Preparatory	38,127	38,046
Secondary	21,653	28,905

Source: United Arab Emirates, Ministry of Planning (1997)

These values indicate that school- age children form 11% of the whole community (United Arab Emirates, Ministry of Planning, 1997).

The number of Governmental schools distributed in the Emirates is shown in Table 1.4.

Table 1.4: Distribution of governmental schools in the Emirates

Emirate	Number of governmental schools
Abu Dhabi	259
Dubai	81
Al Sharjah	106
Ajman	36
Umm El Quwain	23
Ras Al Khaimah	89
Al Fujairah	45

Source: United Arab Emirates, Ministry of Planning (1997)

1.8. Health Service

The development of the health service has been very slow. This region has only known modern medicine recently, thus patients were treated by folklore medicine that was applied by Arabs for a long time. This medicine depended mainly on herbs from the desert and cauterisation.

In the past three decades, there has been a great improvement in health indices. In 1971 there was little available to the general population by way of organized medical treatment: 7 hospitals with 70 beds and 12 medical centres to care for the total population of the UAE. By 1998 this had changed and the UAE's citizens can now avail themselves of one of the best health care services in the world, largely free of charge. By 1998 there were 54 hospitals with total 6877 of beds, 115 primary health care centres, one doctor/600 population and one nurse/300 population.

Recent United Nations (UN) reports indicate that the UAE is one of the top eight countries in the Middle East and North Africa in the field of medicine and child care. Life expectancy has increased from approximately 55 years in the 1950s to 76 years for females and 74 years for males in 1998. Infant mortality rate was 9.44/1000 in 1998 which is much less than the international target rate 70/1000,whilst the child mortality rate was 19/1000 in 1998 compared to an international rate of 89/1000.

CHAPTER TWO: LITERATURE REVIEW

The high prevalence of obesity worldwide in children, adolescents and adults causes major health and economic problems in the community. This review will concentrate on the definition, prevalence, aetiology, health and economical risks, followed by the prevention and treatment of obesity.

2.1. Definition of obesity

The definition of obesity may differ depending on the human condition in which it is used. In adults, the definition is simple and precise. Any adult who has a body mass index (BMI) greater than 30kg/m^2 is classified as obese, and overweight if BMI ranges between 25.0-29.9 kg/m^2, according to the cut-off points proposed by the World Health Organization (WHO) in 1997 (WHO, 1998) (Table 2.1). These cut-off points are derived from the mortality data on a reference population.

Table 2.1: WHO cut-off points for the classification of overweight and obesity

BMI (kg/m^2)	WHO Classification
< 18.5	Underweight
18.5-24.9	Normal
25.0-29.9	Overweight
30.0-34.8	Obese class I
35.0-39.9	Obese class II
≥ 40.0	Obese class III

In children and adolescents, the definition of overweight or obesity is more difficult due to the growth phases the child goes through. However, even in this population most studies depend on BMI to define overweight and obesity. Generally, in children and adolescents, the 85th and 95th centiles of BMI for age and sex have been used as cut-off points, although a few studies have used >120% weight/ideal weight as a measure of overweight or obesity (Tables 2.2 and 2.3).

The International Obesity Task Force (IOTF), established in 1994 to combat the increase in the worldwide prevalence of obesity, held a workshop on childhood obesity to determine the most suitable method for the assessment of obesity in children and adolescents. It was agreed that BMI afforded a reasonable guide to assess fatness in children and adolescents (Dietz and Bellizzi, 1999).

2.2. Prevalence of obesity

The prevalence of overweight and obesity in children and adolescents is increasing rapidly in the developed and developing countries. In developed countries, many studies have shown an increase in the prevalence of overweight and obesity among children and adolescents. Table 2.2 summarises some of these studies.

Table 2.2: Trends in the prevalence of overweight or obesity for children and adolescents in developed countries

Country	Reference	Age (yr)	Findings
United States	Gauthier *et al.* (2000)	6-19	Overweight (BMI >85th centile) 20% and 19% for boys aged 6-11 yrs and 12-19 yrs respectively, and 20% and 18% for girls aged 6-11yrs and 12-19 yrs respectively.
Canada	Hanley *et al.* (2000)	2-19	Overweight (BMI ≥85th centile) 28% for boys and 34% for girls.
Germany	Kromeyer *et al.* (1999)	7-14	Overweight (BMI >90th centile) increased from 10% to 16% for boys and from 12% to 21% for girls. Obesity (BMI >97th centile) increased from 5% to 8% for boys and from 5% to 10% for girls
UK	Reilly and Dorosty (1999)	6-15	Overweight (BMI >85th centile) ranged from 22% at age 6 yrs to 31% at age 15 yrs. Obesity (BMI >95th centile) ranged from 10% at age 6 yrs to 17% at age 15 yrs.
Brazil	Fonseca *et al.* (1998)	15-17	Overweight (BMI >90th centile) 7% for girls and 24% for boys.

Table 2.2 (continued)

China	Wang *et al.* (1998)	10-18	Overweight (BMI >85th centile) 4% for boys and girls
Hong Kong	Leung *et al.* (1995)	3-18	Obesity (>120% weight for height) 11% for boys and 9% for girls.
Finland	Nuutinen *et al.* (1991)	9-18	Obesity (> 90th centile for BMI and triceps skin fold) 4% and 2% for boys and girls aged 9-18 yrs respectively and 4 and 3% for boys and girls for BMI and subscapular skinfold thickness.

In developing countries, overweight and obesity have become a public health problem of increasing importance and the range of the problem continues to be undetermined.

Studies have been conducted in many Middle East countries to estimate the prevalence of overweight and obesity in adults (El Mugamer *et al.* 1995; Al-Isa, 1997; Al-Mannai *et al.* 1996; and Ajlouni *et al.* 1998). In contrast, few studies have been conducted to determine the prevalence of obesity in children and adolescents in Bahrain, Saudi Arabia, Kuwait and Tunisia as shown in Table 2.3. To date, no such studies have been conducted in the United Arab Emirates.

Table 2.3: Trends in the prevalence of overweight and obesity for children and adolescents in the Middle East countries

Country	Reference	Age (years)	Findings
Tunisia	Mokhtar *et al.* (2001)	11-19	Overweight (BMI ≥85th centile) 10% for girls aged 19 years and 5% for boys aged 19 years.
United Arab Emirates	Al-Haddad *et al.* (2000)	6-16	Overweight (BMI 85th -<95th centiles) 9% for boys and girls. Obesity (BMI ≥ 95th centile) 8 for boys and girls
Kuwait	Al-Mousa and Parkash (2000)	10-17	Overweight (BMI ≥85th centile) and obesity (BMI ≥95th centile) 36% and 37% for girls and boys aged 10-13 years respectively; 31% and 28% for girls and boys aged 14-17years respectively.
Bahrain	Musaiger *et al.* (2000)	12-19	Overweight (BMI >85th centile) 39% in girls. Obesity (>95th centile) 6% in girls.
Saudi Arabia	Abahussain *et al.* (1999)	12-19	BMI (assumed cut-off point >85th centile) 28% of girls were overweight or obese.
Saudi Arabia	Al-Nuaim *et al.* (1996)	6-18	Overweight (BMI >85th centile) 12% in boys. Obesity (BMI >95th centile) 16% in boys.

2.3. Assessment of body fat

Many methods have been used to assess body fat levels, including anthropometry, bioelectrical impedance analysis and others such as underwater weighing. Anthropometric remains the first choice for body fat assessment due to its simplicity and ease of application to a population.

Anthropometry: is the study and technique of making human body measurements, especially for use on a comparative or classification basis.

It has many benefits as a tool to assess nutritional status, including:

- inexpensive;
- the tools are easy to use and transport (scales, tapes and callipers);
- safe to use;
- training of staff is very brief.
- relatively non invasive.

The link between anthropometry and obesity and the relationship between overweight and life expectancy may have been observed since the first decades of the last century (Roche, 1984). Insurance companies developed the first height and weight table in 1908 with the Metropolitan Life Insurance Company introducing the term "Ideal Weight for Men and Women" in 1942-1943.

2.3.1. Body weight

Measurement of body weight was the first method known to define overweight or obesity. The Metropolitan Life Insurance Company (MLIC) introduced the table of weight for height in 1959, called "Desirable Body Weight Ranges". This table contained data from 26 life insurance companies in the United States and Canada from 1934-1954 and involved observation of 5 million participants insured during 20 years.

The table consisted of 3 columns: the first one expressed the height, in feet and inches without shoes; the second displayed the weight of men in pounds and the third the weight of women in pounds. Weight of both sexes appeared in the form of ranges (lowest and highest). This table is appropriate to persons aged 25-59 years, regardless of frame size (Table 2.4).

Table 2.4: Desirable body weight ranges

Height		Men		Women		Height
Ft	In	L b	Kg	L b	Kg	Cm
4	9			94-106	42.7-48.2	145
4	10			97-109	44.1-49.5	147
4	11			100-112	45.5-50.9	150
5	0			103-115	46.8-52.3	152
5	1	111-112	50.5-55.5	106-118	48.2-53.6	155
5	2	114-126	51.8-57.3	109-122	49.5-55.5	157
5	3	117-129	53.2-58.6	112-126	50.9-57.3	160
5	4	120-132	54.5-60.0	116-131	52.7-69.4	162
5	5	123-136	55.9-61.8	120-135	54.5-61.4	165
5	6	127-140	57.7-63.6	124-139	56.4-63.2	167
5	7	131-145	59.9-65.9	128-143	58.2-65.0	170
5	8	135-149	61.4-67.7	132-147	60.0-66.8	172
5	9	139-153	63.2-69.5	136-151	61.8-68.6	175
5	10	143-158	65.0-71.8	140-155	63.6-70.5	177
5	11	147-163	66.8-74.1			180
6	0	151-168	68.6-76.4			182
6	1	155-173	70.5-78.6			185
6	2	160-178	72.7-80.9			187
6	3	165-183	75.0-83.2			190

Source: Multi-Diet Home (2001)

In 1983 a revised table was proposed, based on the data of 25 life insurance companies, also in United States and Canada from 1954-1972, and involved approximately 4.2 million insured participants. Frame size was introduced in these tables, called "1983 Metropolitan Height and Weight Tables". These tables were divided into small, medium and large frame size, measuring elbow width to estimate the frame size (Gibson, 1990).

In both sets of tables, applicants with major health conditions, such as diabetes mellitus, were excluded and weight ranges were associated with the lowest mortality rate. A cut-off point was often used for separating obese from non-obese, is a relative weight of 120% of the desirable weight.

An alternative approach for appropriate ranges of body weight in relation to height is the Quetlet Index or Body Mass Index (BMI) (Pi-Sunyer, 2000). This is the weight, in kilograms, divided by the square of the height, in metres.

This approach has been used among all age groups from childhood through to adulthood with no sex differences. As any method of measurement, it has advantages and limitations. It may show false positive results in athletes (muscular) and in short people <1.52 metre in height (Pi-Sunyer, 2000). An increase in BMI has been well correlated with many diseases, such as type 2 diabetes mellitus (Bonham and Brock, 1985), hypertension (Gilbert *et al.* 1996), cancer (Shike, 1996) and cardiovascular diseases (Bonora *et al.* 1997) and also it is highly correlated with percent body fat (Goran *et al.* 1996).

2.3.2. Body circumferences

Measurement of circumferences has been used to obtain information about body fat and its distribution. Waist, hips and mid-upper-arm circumferences (MUAC) are the most well known measures of obesity.

There are two major types of fat distribution in the adult body. Fat stored mainly around the hips and thighs, giving a pear shape, is known as gynoid distribution and was first defined by Vague (Bjorntop, 1987). Fat stored mostly in the abdomen, producing an "apple shape" is known as android distribution and is found mainly in males.

Many studies have discussed the relationship between waist circumference and/ or waist:hip ratio and obesity (Lean *et al.* 1995). Measurement of waist circumference describes the distribution of both subcutaneous and intra-abdominal adipose tissue.

This measurement is usually taken mid-way between the superior iliac crest and the rib cage in the mid auxiliary line, with the person breathing normally. The elastic tape stays in position around the abdomen about the level of the umbilicus, and the measurement is recorded in centimetres. The hip circumference is the maximum circumference over the buttocks; this measurement is also recorded in centimetres (Jones *et al.* 1986 and Gibson 1990).

The waist circumference and the waist: hip ratio have both been used for assessment of visceral fat as a risk factor for chronic diseases. Many cut-off points for waist hip ratio (WHR) have been proposed, >0.95 for men and >0.8 for women (Solomon and Manson, 1997). Lately, research has indicated that the measurement of waist circumference alone might be sufficient to define obesity and other health problems (Lean *et al.* 1998). The sex-specific cut-off points are >102cm (>40in) for males and >88cm(>35in) for females (National Heart, Lung and Blood Institute, 1998).

2.3.3. Skinfold thickness

Skinfold thickness is one measurement used to estimate total body fat. Callipers are used to measure the thickness of subcutaneous fat. The earliest calliper used was known as the Franzen calliper in 1929 (Cameron, 1984).

The sites used to measure skinfold thickness are:

- Triceps skinfold: measured at the mid-point of the back of the upper non-dominant arm;
- Biceps skinfold: measured at the opposite of the triceps skinfold, being on the anterior aspect of the non-dominant arm;
- Subscapular skinfold: measured below the inferior angel of the scapula;
- Suprailiac skinfold: measured above the anterior superior iliac spine;
- Mid-auxiliary skinfold: measured at the mid-auxiliary line at the level of the xiphoid process.

There are many other sites including abdominal, chest, cheek, chins, and thigh. However, there is no agreement on the best single, or combination of skinfold sites to assess body fat (Gibson, 1990).

2.3.4. Other techniques to estimate body composition

Body composition techniques have evolved through various stages, when it was first observed that young children contain lower amounts of ash (minerals) and higher amounts of water compared when with old people.

Many methods are currently available for estimating body composition in living human beings (Ellis, 2000). The selection of any method depends on many factors including cost, convenience, health and age of the subjects, size of the sample, precision and accuracy and the aim of the study.

Appendix 2.1 summarises the most common methods used in estimation of body composition.

2.4. Aetiology of obesity

As the prevalence of obesity increases dramatically worldwide, environmental factors rather than genetics have been suggested as a major cause of obesity (Hill and Peters, 1998).

The environmental factors can be divided into 2 subgroups: energy intake (food intake) and energy expenditure (physical activity).

Food intake is composed of two parts, the quantity of the food and the quality of the food (nutrients, and mainly macronutrients, especially fat). Nowadays, food is available in unlimited amounts and is relatively inexpensive as a result of modern food industry. The food industry produces ready-to-eat meals, high-energy dense foods and many types and attractive forms of foods, which may encourage people to consume more food. In addition, the role of food marketing in the mass media and the encouragement of fast food restaurants to consume a large portion of foods through announcements, such as "Foods until Replete" or "Go to large Size", contribute to an increase in food consumption.

Salbe and Ravussin (2000) grouped the causes of obesity into three groups:

1. Behavioural influences: activity level, nutrition, smoking status and socio-economic status.
2. Metabolic influences: genetic and metabolic/ endocrine factors.
3. Biological influences: race, gender, age, and pregnancy status.

2.4.1. Energy balance

Energy balance = energy intake - energy expenditure

Body weight is a situation of energy balance over a period of time. Energy balance is determined by three different factors: macronutrient intake (carbohydrate, fat and protein); energy expenditure; and energy or nutrient partitioning (Bouchard, 2000). If positive or negative balance occurs over a period of time, weight gain or weight loss will result. The energy requirement of an individual has been defined as " the level of energy intake from food that will be balance energy expenditure when the individual has a body size and composition, and level of physical activity, consistent with long-term health; and that will allow for the maintenance of economically

necessary and socially desirable physical activity" (FAO/WHO/UNU 1985).

2.4.1.1. Energy expenditure

The energy expenditure of an individual over a whole day can be divided in to 3 components:

(1) basal metabolic rate (BMR), which is the largest component accounting for 60-70% of the total energy expenditure (TEE);

(2) physical activity, accounting for 20-40% of the total energy expenditure (TEE);

(3) postprandial thermogenesis (PPT).

In growing subjects, such as children and adolescents, growth is the fourth part of TEE, which accounts for approximately 4% of TEE as shown in figure 2.1

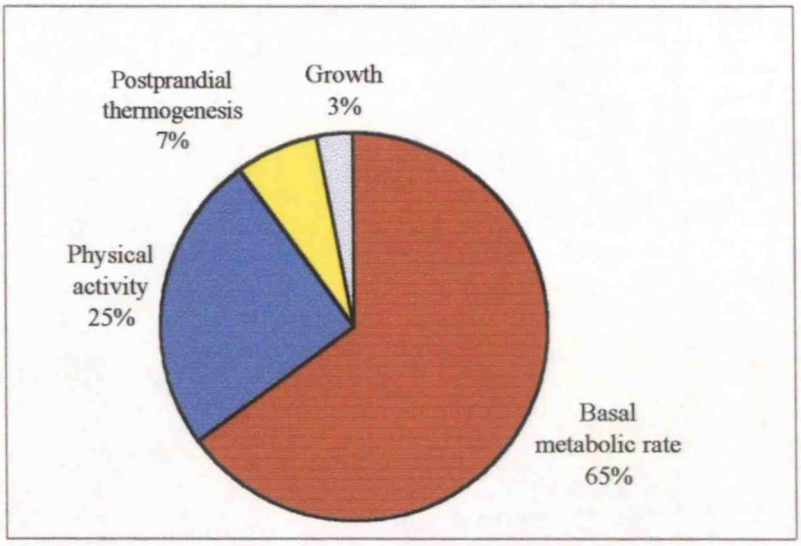

Figure 2.1: The components of total energy expenditure in growing subjects

2.4.1.1.1. Basal metabolic rate

BMR is the minimum rate of energy needed to sustain life: respiration, heartbeat, and maintenance of body temperature. BMR should be measured under standardised conditions as follows (McNeill, 2000):

1. Lying at complete physical and mental rest.
2. The measurement should be carried out in a warm environment.
3. BMR should be measured at least 12 hours after the last meal.
4. Heavy activity should be avoided in the day prior to the measurement.

5. The measurement should be carried out 12 hours after the consumption of any stimulants, such as tea, coffee or cigarettes.

2.4.1.1.1.1. Factors affecting BMR

Many factors influence TEE and therefore BMR (Figure 2.2). Age, body size, gender and hormonal status are known to be the main factors affecting individual variation in TEE. Some of these will be discussed below:

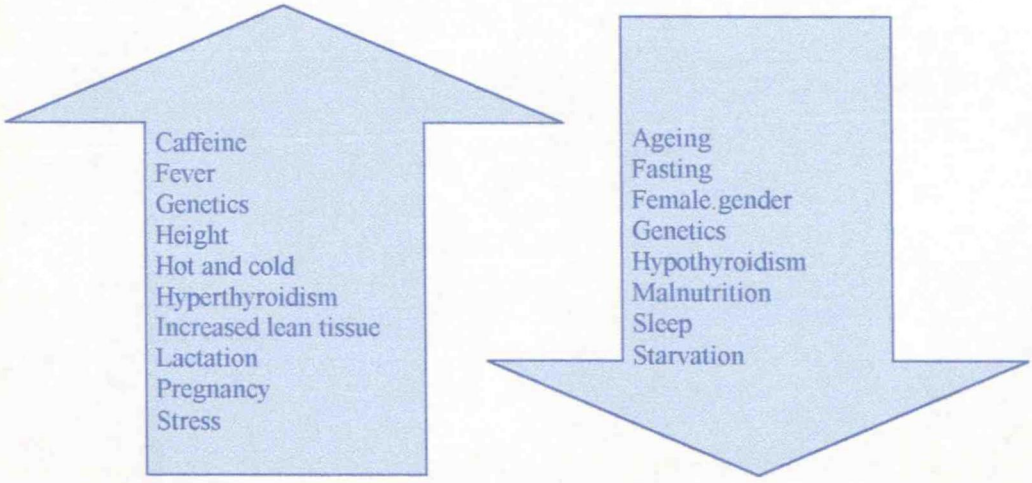

Figure 2.2: Factors affecting BMR.

(1) Age: There is a gradual fall in metabolism during adult life as age increases. Table 2.5 shows the extent of the decrease in BMR with age. BMR per kilogram is higher in children than in adults because they have a high proportion of very active tissues, such as the brain and liver. Children utilise energy to maintain their body temperature and for the expenditure of growth, which is approximately 21 kJ/g of normal weight gain (McNeill, 2000). During adulthood there is a decline in fat free mass and an increase in adipose tissue, which account for the fall in BMR. Lean body mass decreases over early adulthood at a rate of about 2-3% per decade (Food and Nutrition Board, 1989). In the elderly, an increase in adipose tissue results in a very low ratio of active tissue to non-active tissue and overall BMR decreases (Hoffman and Sawaya, 1999).

Table 2.5: Changes in BMR with age

Age (years)	BMR (kcal m^{-2} h^{-1})	
	Male	Female
2	57.0	52.5
6	53.0	50.6
8	51.8	47.0
10	48.5	45.9
16	45.7	38.8
20	41.4	36.1
30	39.3	35.7
40	38.0	35.7
50	36.7	34.0
60	35.5	32.6

Source: Wright (1982).

(2) Sex: generally females have lower BMR than males. This may due to the difference in body size and composition. The difference in body composition between males and females becomes greater throughout adolescence; after maturity men have more muscle mass than women. In a healthy man, about 15-18% of his body weight is adipose tissues and in women about 20-25% of her body weight is adipose tissue (Bray, 1996). The higher the adipose tissue the lower the BMR. The BMR of a 65-kg adult man will be around 1MJ/ day higher than a woman of the same age and weight (McNeill, 2000).

(3) Climate: climate affects energy expenditure due to the energy cost of maintaining body temperature. Some of the factors involved include air temperature, wind speed and radiant temperature of the surroundings (McNeill, 2000). The decrease in the surrounding temperature below 25° C and the increase above 30°C will affect the TEE. The decrease in surrounding temperature will increase heat production to maintain body temperature in the cold climate, whilst, in the hot climate, the increase in energy expenditure is due to the energy cost of sweating and an additional metabolic load of about 5% as a result of sweat gland activity (Johnson and Coward-McKenzie, 2001).

(4) Sleep: TEE declines with sleep. Sleep lowers metabolic rate by about 10% (Blaxter, 1989). The FAO/WHO/UNU recommendations for energy requirements assume that the energy cost of sleep is equal to BMR (Goldberg *et al.* 1988). In contrast, Garby *et al.* (1987) suggested that the energy expenditure of sleep is 0.95 * BMR.

(5) Hormonal changes: hormonal status can affect BMR, especially endocrine disorders such as hypothyroidism and hyperthyroidism. In females, variation of BMR with the menstrual cycle has been reported (Webb, 1986).

(6) Ethnicity: the ethnicity of the individuals may affect the BMR. Schofield (1985) and Piers and Shetty (1993) reported that Indians and Chinese and Americans had BMR lower than Europeans. The definite cause for this difference is not known - whether it is due to genetic, body composition or environmental factors.

2.4.1.1.1.2. Estimation of BMR

A number of methods for the measurement of BMR are known. Those methods can be classified into two categories: (1) direct calorimetry and (2) indirect calorimetry

1. Direct calorimetry.

This was the first method used for the measurement of energy expenditure. A calorimeter is a device for measuring the heat emitted by something. A human calorimeter measures the heat given off by a person.

The calorimeter measures energy expended directly for 24 hours and involves the measurement of heat loss by radiation, convection, conduction, heat of vaporised water from the lungs and skin, and the heat combustion of urine and faeces.

In 1780, Lavoisier, a French chemist, built the first direct animal calorimeter for measuring the energy expenditure in guinea pigs, while the first human calorimeter was built by Atwater in 1892. More than 36 human calorimeters have been built from 1889 until the present day (Webb, 1985).

Within the calorimeter, the subject is restricted to an insulated double-walled chamber. The temperature of the two walls is kept equal so that heat cannot flow in either direction. Dry heat loss is calculated from the difference in temperature and

amount of water flowing in and out of the pipes. Heat removed by vaporisation of water is calculated by measuring moisture of air leaving the calorimeter (Pike and Brown, 1984).

A modern method was developed which depends mainly on water-cooled piece of clothing where the heat loss can be detected in the water and breath (McNeill, 2000). It is considered the gold standard for measuring energy expenditure; nevertheless, it is no longer widely used because the structure is costly and subjects must remain in a physically restricted environment for a long period.

As any method of measurement, it has advantages and limitations. The advantages and limitations are shown in table 2.6.

Table 2.6: Advantages and disadvantages of whole-body direct calorimetry

Advantages	Disadvantages
Accurate	Must account for heat transfer in food, drink, excreta, lighting, television etc, which may be 10% of total.
Precise	Expensive
Fast-responding	Complex mechanical engineering
Direct energy measurement	Provides no information about substrates from which energy is derived
Good environment for strictly controlled studies	Not easy to combine with invasive measurements
	Artificial environment

Source: Murgatroyed *et al.* (1993).

2. Indirect calorimetry

Indirect calorimetry measures oxygen consumption and carbon dioxide production. The ratio between the volume of CO_2 produced and the volume of O_2 consumed is known as respiratory quotient (RQ). The determination of RQ provides some indication of the fuel mixture oxidized and therefore provides a more accurate estimate of the energy equivalence of O_2. RQ ranges between 0.7 for fat to 1.0 for carbohydrate (Manore and Thompson, 2000).

Many ambulatory, laboratory and bedside indirect calorimetry methods for the estimation of energy expenditure have been developed. Some of these methods are summarised in table 2.7.

Table 2.7: Indirect calorimetric methods

Methods	Description
Whole body	A small-ventilated room is designed to allow the subject to practice some of the activities of their normal day. It is a highly accurate method. It can be carried out only in laboratories.
Ventilated hood	The subject lies down on a bed and is covered by a hood or a tent for the whole body. This method is easy to use and is suitable for healthy subjects and patients.
Douglas bag	The subject breathes into a mouthpiece attached to a tube, which leads to a bag with a capacity of up to 150 L. This method is easy to use and is inexpensive. This method can be used both in the field and in laboratories.
Max Planck or Kofranyi- Michhaelis Respirometer	A small sample of the subject's expired air is stored in a butyl rubber bag for analysis in the laboratory. This method can be used in the field.
Oxylog	The subject is attached to a mask, which is attached to a 2.2 Kg polarographic oxygen electrode. The difference between inlet and outlet oxygen is used to calculate the energy expenditure. This is an expensive method; it can be used in the field.
Cosmed K2 system	This system is the same as the Oxylog, but with lighter weight (400 g). The data is transmitted directly to a computer program. The method is very expensive; it can be used in the field.
Labelled bicarbonate	The subject wears a small pump, which infuses labelled bicarbonate ($NaH^{13}CO_3$) into the body. Collected samples of blood, breath or saliva give information on the extent of the isotopes in the produced CO_2.

Doubly labelled water (DLW) measures TEE only and depends mainly on the utilisation of stable isotopes. The subject drinks a small quantity of water containing a known amount of non-radioactive isotopes of deuterium ($^2H_2$) and oxygen (^{18}O). The

isotopes mix with the normal hydrogen and oxygen in the body within a few hours. As energy is used up in the body, carbon dioxide (CO_2) and water are produced. The CO_2 is lost from the body only by breathing, while the water is lost by breathing, urine, sweat and defecation. Oxygen is lost more rapidly than hydrogen because it is available in molecules, water and the CO_2. The difference between the rate of loss of ^{18}O and ^{2}H is used to calculate the CO_2 output to determine the TEE (McNeill, 2000).

The minimum study duration is 12-14 days for adults and 6-7 days for children (Hughes *et al.* 1999). DLW has been used as a gold standard for validating other methods to measure TEE (Johnson and Coward-McKenzie, 2001).

2.4.1.1.1.3. Prediction of BMR

BMR plays an important part in the estimation of energy requirements in humans. Many equations based on body weight, height, sex and age have been used to predict BMR in adults as well as in children (Manore and Thompson, 2000). Different equations are commonly used in the prediction of BMR. These equations were formulated based on BMR data obtained between 1919 and 1952 (Wong, *et al.* 1996).

Harris-Benedict equation: In 1919, Harris and Benedict proposed two predictive equations for basal energy expenditure (BEE) for males and females:

Men BEE (kcal/day)= 66.4730+13.7516 (W)+5.0033 (H)-6.7550 (A).

Women BEE (kcal/day)= 655.0955+9.5634 (W)+1.8496 (H)-4.6756 (A)

Where W=weight in kilogram H= height in metres and A=age in years.

However, the Harris-Benedict equations overestimate the BMR by at least 5% (Frankenfield *et al.* 1998).

Many equations have been developed to predict BMR. Some of these depend on he data obtained from Harris-Benedict equations. More recent equations include those of the FAO/WHO/UNU (1985) (Table 2.8), Schofield (1985)(Table 2.9).

Table 2.8: FAO/WHO/UNU equations for the prediction of BMR

Age range (years)	Males		Females	
	kcal/ day	MJ/ day	kcal/ day	MJ/day
0 – 3	60.9W – 54	0.255W – 0.226	61.0W –51	0.255W – 0.214
3– 10	22.7W + 495	0.0949W + 2.07	22.5W + 499	0.0941W + 2.09
10 – 18	17.5W + 651	0.0732W + 2.72	12.2W + 746	0.0510W + 3.12
18 – 30	15.3W + 679	0.0640W + 2.84	14.7W + 496	0.0615W + 2.08
30 – 60	11.6W + 879	0.0485W + 3.67	8.7W + 829	0.0364W + 3.47
> 60	13.5W + 487	0.0565W + 2.04	10.5W + 596	0.0439W + 2.49

Where W=weight in (Kg). Source: FAO/WHO/UNU (1985)

Table 2.9: Schofield equations for the prediction of BMR

Age group (years)	BMR (MJ/ day)	
	Males	Females
< 3	0.0007W + 6.349H – 2.584	0.068W + 4.281H – 1.730
3 – 10	0.082W + 0.545H + 1.736	0.071W + 0.677H + 1.553
10 – 18	0.086W + 0.574H + 2.157	0.035W + 1.948H + 0.837
18 – 30	0.063W + 0.042H + 2.953	0.057W + 1.184H + 0.411
30 – 60	0.048W + 0.011H + 3.670	0.034W + 0.066H + 3.530
> 60	0.038W + 4.068H – 3.491	0.033W + 1.917H + 0.074

Where W=weight in (Kg) and H=height (m). Source: Schofield (1985)

2.4.1.1.1.1.1. Measurement of TEE

In addition, to measuring of BMR, there are a number of methods such as non-calorimetric methods used to measure TEE.

(i) Heart rate monitoring (HRM)

HMR is used to assess energy expenditure in humans under free-living conditions. It depends on the linear relationship between heart rate (HR) and oxygen consumption (VO_2) (Melanson and Freedson, 1996). Physiological status (pregnancy

and lactation), humidity, emotional status, ambient temperature, and body position cause changes in HR independent of VO_2 and this is considered one of the major limitations of this method.

Special electrodes, connected to the chest, transmit data to a remote unit, which is able to store minute-by-minute HRs for many hours. A problem with this measurement is that the relationship between heart rate and oxygen consumption is not accurate in sedentary or strenuous activities (Melby *et al.* 2000). To overcome this, it is necessary to establish HR and associated VO_2 rates for each subject and develop a regression equation to determine the energy expenditure (Torun, 1996).

(ii) Motion sensors

The use of motion sensors presumes that the movement of the limbs or the whole body estimates TEE. It is suggested that the movement of limbs reflects TEE (Melanson and Freedson, 1996).

Special devices designed to register data on physical activities can be easily attached to the belt, ankle, and wrist. Many types of motion sensors are known, for example a pedometer records the number of footsteps taken with each vertical displacement of the hip that occurs during ambulation (Leenders *et al.* 2000). The actometer, large-scale integrators, accelerometers, and three-dimensional activity monitors are all motion sensors devices.

(iii) Observational methods:

The observational method is a method whereby an observer records the physical activity of the subjects while watching the subject. Observers can record the behavioural information, type of activities, and time per activity. It is used to estimate energy expenditure and physical activities. It has been used to measure and rank children's activities as it is difficult to depend on children to record or recall their daily physical activities. Therefore, this method is suitable for pre-school and young children (Pate, 1993). The cost of this method is expensive, because of the cost of an observer for each subject, it is time consuming and not suitable for studying large populations.

(iv) Self-reporting estimates

This includes all types of questionnaires, diaries and interviews and is designed for large-scale studies. Advantages include inexpensive, not conflicting with daily

activities and it can differentiate between many types of activities. One of the main disadvantages of this method is that it is not recommended for use in children under the age of 10 years because it is difficult for this age to record their physical activity (Fox and Riddoch, 2000). In addition, memory errors may occur on that rely on recall. Studies on activity surveys may incorporate the activities of 3 days (Bouchard *et al.* 1983), seven days (Bratteby *et al.* 1997a), or 2-weeks (Schulz *et al.* 1989).

2.4.1.1.2. Physical activity

Physical activity is the second component of TEE, providing 20-40% of TEE. Physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen *et al.* 1985) and it can be categorised into occupational, household, and leisure time. The energy expended in the activity depends on the type of the activity, time, and body size (Department of Health and Human Services, 2001).

The energy costs of activities are usually expressed in kJ/ min, or as a multiple of BMR (PAR, physical activity ratio). Two publications give estimates for energy costs of different activities (Ainsworth, 2000 and James and Schofield, 1990).

Many methods are used for the assessment of physical activity including:

1. Doubly labelled water.
2. Self-reporting: activity surveys, diaries and interviews.
3. Observational methods.
4. Heart rate monitoring.
5. Motion sensors such as pedometers and accelerometers (Melanson and Freedson, 1996).

Activity surveys are practical for assessing physical activity in large populations, due to the lower cost, easy to conduct and acceptable by most of the participants (Melanson and Freedson, 1996).

The physical activity level (PAL) is a means of providing information about relative differences in usual levels of physical activity (Melby *et al.* 2000). The PAL is calculated as TEE divided by BMR. The lowest PAL is around 1.55 for sedentary males (Melby *et al.* 2000) and 1.44 for girls aged 1-5 years old (Torun *et al.* 1996). The PAL can reach 3.5-4.5 under extreme exercise conditions (Melby *et al.* 2000).

2.4.1.1.3. Postprandial Thermogenesis (PPT)

PPT is known as *specific dynamic action* or *thermic effect of food* (McNeill, 2000). The thermic effect of food is defined as "the stimulation of metabolism that occurs up to three to six hours after a meal as a result of the processing of the food in the stomach and intestine and of nutrients in the blood and body cells" (Raaij, 1998). PPT is essential for the digestion, absorption, transport, metabolism and storage of consumed nutrients (McNeill, 2000).

In general, PPT is assumed to be 6-10% of the TEE (Manore and Thompson, 2000). PPT depends on the composition of the meal in terms of macronutrients, the size of the meal, the nutritional and health status of the subjects (Manore and Thompson 2000).

PPT can be divided into two categories: (1) obligatory thermogenesis and (2) facultative thermogenesis (Raaij, 1998). The obligatory thermogenesis is due to the energetic cost of glucose storage (which mainly occurs as glycogen); the second has been called facultative thermogenesis and is dependent upon sympathetic nervous system.

Sympathetic nervous system (SNS) has a role in the regulation of thermogenesis in the context of cold exposure, maintenance of body temperature and dietary intake. The role of SNS in the regulation of dietary-induced thermogenesis is reasonably well established in the laboratory animal. Available evidence suggests an important role in larger mammals, including man. Excess caloric intake stimulates sympathetic nervous system activity in a variety of organs including brown adipose tissues. Sympathetic stimulation of brown adipose tissue is importantly involved in the changes in thermogenesis that accompany changes in dietary intake.

2.4.1.1.4. Growth:

Growth is the fourth component of TEE. Growth has a consideration in the calculation of energy requirements of infants, children and adolescents. In children, an addition to the basal metabolism is required for growth, which is about 21 kJ/g of tissue gained, which is approximately 250 kJ/day (Raaij, 1998).

Human growth consists of two main stages in the life cycle (Bogin, 1999),

firstly prenatal, which includes fertilization and birth and secondly postnatal, which includes neonatal, infancy, childhood, juvenile, puberty, adolescence, adulthood, and old age and senescence.

Among these stages, infancy and adolescence experience a rapid growth velocity. Infancy (first 3 years) is characterized by the most rapid velocity of growth; during the first year of life, height increases by about 50% (Sinclair, 1991). Adolescence is the last stage to experience rapid growth. A sudden increase in height, "adolescent spurt", in boys starts at 12 ½- 13 years of age and height increases by 20cm. This adolescent spurt starts earlier in girls than in boys at 10 ½ -11 years of age and height increases by 16cm (Sinclair, 1991). Figure 2.3 shows the height gain in cm per year.

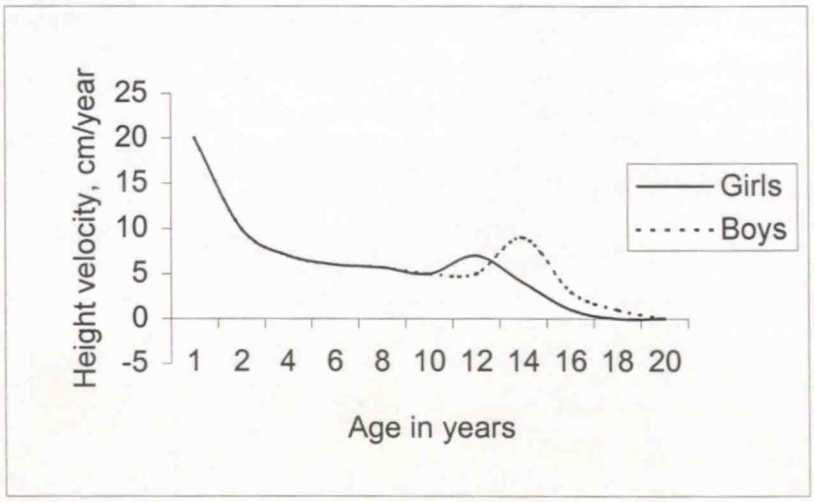

Figure 2.3: Height velocity in boys and girls

As the growth spurt is highest among adolescents, growth patterns should be controlled through out this important period of the life cycle.

Dietz (1994) identified three critical periods for the development of obesity:

(1) prenatal period.
(2) adiposity rebound period (5-7 years of age).
(3) adolescence period.

In the prenatal period, it was noticed that mothers who were exposed to famine during the third trimester protected their offspring against obesity, in contrast to the mothers who were exposed to famine during the first and second trimesters. It was

suggested that as the development of the hypothalamus occurs during the first trimester, a reduction in food intake would disturb this development. The hypothalamus is involved in the control of food intake. In addition, the replication of adipocytes occurs during the third trimester (Dietz, 1994). Therefore, early undernutrition may impair the regulation of food intake and predispose obesity while undernutrition during the third trimester doesn't predispose obesity because adipocytes replication occurs in this period.

In the second critical period (5-7 years), adiposity rebound is defined as the onset of the second period of rapid growth in body fat (Salbe and Ravussin, 2000). Around the age of 5 years of age BMI starts to increase. Three possible explanations have been proposed (Dietz, 1997), firstly, this period is characterized by behavioural development to food intake or activity; secondly, children who were exposed to rebound adiposity were offspring of mothers of gestational diabetes; and thirdly, it may reflect early maturation (early menarche).

Adolescence represents a period of increased risk for the development of obesity, especially in girls and changes in body fat (Dietz, 1997). Braddon *et al.* (1986) reported that 10% and 30% of adult obesity in men and women respectively begins in early adolescence.

The relative contribution of each growth period to the prevalence of obesity is not certain. Therefore growth during childhood and adolescence should be monitored as part of the control of obesity.

2.4.1.2. Energy intake

Food is a mixture of nutrients needed for many purposes, including normal growth and development, maintaining cells and tissues, supply of energy and regulating body processes (Shetty, 1999).

Food intake depends on many factors, such as availability of food, palatability, social and cultural factors, familial and cultural influences, psychological state and the composition of the meal (Hoffman and Sawaya, 1999). Measurement of food consumption may be carried out at different levels such as national, household and individual levels.

Estimation of energy and nutrient intakes are proposed for specific goals, including the estimation of the adequacy of food supply, the assessment of intakes of specific nutrients of populations and groups, collection of information on food habits, assessing the relationship between diet and health such as high energy intake and obesity, comparison between different populations and evaluation of nutrition education, nutrition intervention and food fortification programmes (Cameron and Van Staveren, 1988).

Different methods can be used to collect information on food consumption. Table 2.10 shows some of these methods for use at different levels.

Table 2.10: Methods for measuring food consumption

National	Household	Individual
Food balance sheet	Food account	Twenty-four-hour-recall
Market databases	List-recall	Estimated food records
Universal product codes	Inventory	Weighed food records
	Household food records	Diet history
	Telephone survey	Food frequency questionnaire
	Family food scale	Direct chemical analysis

2.4.1.2.1. Individual food consumption

Measurement of individual food consumption can be classified as quantitative or qualitative (Gibson, 1990), and retrospective or prospective (Pao, 1989).

2.4.1.2.1.1. Retrospective or food recall methods

The following methods depend on dietary information given from memory by the subject

1. Twenty-four-hour recall

The 24-hour recall remains the most widely used approach for collecting food intake data. This method was first introduced by Burke in 1938 (Cameron and Van Staveren, 1988) and was designed to evaluate the recent food intake quantitatively and qualitatively during a specific period of time, usually 24 hours. In this method, the subject is asked to report from memory the types and amounts of foods and drinks ingested during the past 24 hours. Food quantities are usually assessed by household measures, such as cups and spoons, food photographs or food models. Information on cooking methods and the consumption of dietary supplements is also included in the interview.

The 24-hour recall is a quick and simple method, requires low subject burden, is inexpensive, can be used in illiterate people and in large populations, and requires short-term memory (Pao, 1989; Thompson and Byers, 1994). As with any method of measurement, it has limitations. These include accuracy as the method depends on the subject's memory, a single day may not be representative of usual intake, inaccurate estimation of portion size, and under- or over-reporting, especially in obese and underweight subjects respectively (Westerterp, 2000).

This method is not appropriate for children under seven years of age, people aged 75 years and over and handicapped subjects with speech or sight problems (Cameron and Van Staveren, 1988).

2. Diet history

The diet history method assesses an individual's usual long-term dietary intake patterns. This period could be the last week, month, or year. This method may also

include a food recall and/ or a food record and a food frequency

Burke et al first developed the diet history method in 1947 (Thompson and Byers, 1994). The diet history may consist of three parts. The first part is typical menu from the subject of foods used in the morning, afternoon, evening, and between meals. The second part is a cross check consisting of a list of foods to verify and clarify all the foods in the first part. The last part is a three-day food record using household measures (Bingham, 1987;Cameron and Van Staveren, 1988).

Information is obtained during an interview that lasts for approximately 1-1.5 hours. The diet history gives more information of long-term intake and is a useful method to study the relationship between disease and food intake as it covers a long period of time.

The major disadvantages of the method are that it is unsuitable for large surveys, it provides qualitative rather than quantitative information on food intake, and it depends on the subject's memory (Pao, 1989).

3. Food frequency questionnaire

Food frequency questionnaire (FFQ) estimates how frequently certain foods are eaten during a specified time period. FFQ contains a checklist of foods or food groups for the subjects to indicate which items are consumed within a specified period, usually over weeks, months or a year. The subject or an interviewer can conduct the FFQ. Some FFQ methods specify the portion size of the foods (Pao, 1989). FFQ has been used in epideoiologic research on diet and disease to assess the usual food or nutrient intakes of individuals and has been applied in research on cancer and cardiovascular diseases (Zulkifli and Yu, 1992).

A FFQ consists of two parts: a food list and a frequency response section for subjects to report how often each food is consumed. The content of the food list and division of frequency response categories depend on the purpose of the study, for example whether an assessment of specific nutrient intake or energy intake is required. In the Harvard University FFQ, the format includes nine frequency categories for foods and portion size is asked as a part of the food item rather than as a separate item (Willett, 1990).

The advantages of FFQ are that it does not require the subjects to be highly trained, is inexpensive, and indicates usual food intake. However, the limitations are that it relies on memory over a long time, is inappropriate for children and may increase subject burden if a lengthy questionnaire is used.

2.4.1.2.1.2. Prospective or food record methods

The following methods require that all foods and drinks consumed be recorded at the time of consumption.

1. Food records

   A food record or food diary provides information on current food intake, usually for a short period of time, for example three or seven days. The amount of foods and drinks ingested are immediately recorded after eating. This method can be divided into three categories: weighed food records; estimated food records; and observed food records (Cameron and Van Staveren, 1988).

   (i) Weighed food records

   Subjects are asked to weigh and record food and drink immediately before consumption and to also weigh and record any leftovers. This method is considered to be the most accurate method to estimate individual food consumption (Cameron and Van Staveren, 1988). This method can be used with children, adults and elderly. However, the major disadvantages of this method are that it cannot be used for illiterate and disabled subjects and subjects may change their usual eating pattern to simplify the weighing method (Cameron and Van Staveren, 1988).

   (ii) Estimated food records

   Subjects are asked to record, at the time of consumption, all food and drink eaten using household measures; in addition the method of food preparation and cooking are noted. The size of the portion can be estimated using standard household measures, such as cups and spoons and counts (for example eggs and bread slices).

   The major advantages over the weighed food record method are that this method is a simple and less demanding method for subjects, is rapid and has

lower costs. However, household measures may reduce accuracy compared with the weighed food record method (Cameron and Van Staveren, 1988).

(iii) Observed food records

If subjects are unable to record their own food intake, an observer may weigh and record the foods to be eaten. This method is suitable for communities who have a definite eating pattern with limited food items in between meals, such as in hospitals and institutions (Cameron and Van Staveren, 1988).

The major disadvantages are that it does not reflect the actual food intake if carried out for one day only, it is time consuming and has higher costs than the weighed or estimated methods.

2. Direct chemical analysis

There are three different methods of collecting data for direct chemical analysis:

- Duplicate portion technique: equivalent portions of all foods and beverages consumed over the set period of time are collected by the subject for direct analysis to estimate the intake of nutrients (Cameron and Van Staveren, 1988).
- Aliquot sampling technique: aliquot samples in a specified proportion of all foods and beverages, are collected over the set period by the subject and subsequently analysed.
- Equivalent composite technique; a combined sample of a raw foods, equivalent to the mean daily amounts of foods eaten, is made up by the investigator for analysis.

One of the main advantages of the direct chemical analysis method is that highly accurate data is obtained in terms of food consumption. However, the limitations are that the method is very expensive, has high investigator burden and is appropriate for a small sample of the population only (Hughes *et al.* 1999).

2.4.1.2.1.3. Techniques in measuring food consumption

Dietary assessment may be a problem in some groups such as children and older people. The following techniques are used to simplify the methods that are used in the assessment of dietary intake.

- Telephone interview: this is considered a useful technique in the collection of dietary information using 24-hour recall or FFQ. Food model portions can be provided before the interview. It is easy to conduct because there is no travelling involved and the required interview time is shorter than that for personal interviews.
- Photographic technique: subjects are asked to photograph, at a specified distance and angle, all the foods and drinks before consumption, including any leftovers. The description of each food/drink and the method of preparation and cooking are also recorded. Estimation of the weights of foods consumed is carried out by viewing the photographs and comparing them with the standard photographs of portions of food/drink of known weights (Gibson, 1990). This is useful in the collection of dietary information for 24-hour recall, however it is an expensive technique.
- Electronic devices for recording food intakes: these were developed to collect quantitative data on food intake of subjects for up to three weeks at home (Stockley *et al.* 1986). The main advantage of this technique is that the subject does not need to keep a written food diary. Tape recording is another technique used to collect dietary intake and has been used to assess children's food intake (Lindquist *et al.* 2000). These methods depend less on memory and advanced cognitive development and can be helpful in 24-hour recall and diet records.

2.4.1.2.1.4. Biochemical markers of food consumption

Biochemical markers or indices can be used in dietary assessment. A biochemical marker is defined as any biochemical index in an easily accessible sample that gives a predictive response to a given dietary component (Gibson, 1990). Many different indices can be used, such as 24-hour-urinary nitrogen excretion, 3-

methylhistidine excretion, urinary mineral excretion (for example, sodium and potassium) and fatty acid content of adipose tissue as a measure of fatty acid composition of the diet (Gibson, 1990).

The role of biochemical markers is to validate other dietary survey methods as these depend on subject's reporting which may affect the accuracy of results. Biochemical markers could potentially replace conventional methods of dietary assessment (Bingham, 1987).

2.4.1.3. Nutrient Partitioning

Food quality includes the caloric content of food of which carbohydrates, protein, and fat are the energy yielding nutrients. Epidemiological data suggest that a diet high in fat is associated with obesity (Bray and Popkin, 1998). Cross sectional studies provide statistical evidence of an association between percentage of dietary fat and body fat in the free-living population. The correlation ranges from +0.17-+0.38 (Lissner and Heitmann, 1995). Results of clinical trials have found that a reduction in the amount of dietary fat is associated with a reduction in mean body weight of -2.54 kg/11 week (Kendall *et al.* 1991) in women aged 25-46 years.

However, some studies do not support these findings. More recently, McCrory *et al.* (2000) suggested that energy density, palatability and dietary variety play a significant role rather than dietary fat in determining energy intake and obesity.

2.4.1.4. Low-physical activity

Low levels of physical activity are associated with an increased risk of obesity (Rippe and Hess, 1998). The reductions in physical activities act on all age groups, children through to adults. Advances in technology and transportation, the attraction of television, electronic games and computers, have increased the time spent in sedentary life (Luepker, 1999). Jebb and Moore (1999) assessed physical activity and dietary intake and their relationship with body weight with data from ecological, cross-sectional and prospective studies. They concluded that there is clear evidence that low levels of physical activity are associated with an increased risk of weight gain and obesity. In addition, a number of studies have found that the prevalence of obesity in

children and adolescents is directly related to the hours of television viewed (McMurray *et al.* 2000).

A low physical activity level is a major determinant of low energy expenditure for the reason that physical activity contributes 20-30% of TEE. Physical activity is the most changeable factor among the three components of the EE - it could be 0% in inactive people and up to 50% in athletes (Molnar and Livingstone, 2000) so it is an important factor in controlling energy balance.

Physical activity levels of the whole population have changed over the past few decades (Hill and Melanson, 1999). The level of physical activities has declined as a result of improvement of technology, cars and other transportation methods replacing walking, household works have been replaced by electrical machines like washing machine, vacuuming, dishwasher and microwaves. In addition, leisure activities such as watching television, computers and video games and the availability of ready - to - use foods have contributed to the decline in physical activity levels.

The participation of other extra physical activities is also affected by the development of technology. Most of the young generation, beginning from childhood until early adulthood, prefer indoor activities, such as watching television, using the computer, and video games (Hill and Peters, 1998).

In view of the fact that obesity has reached an epidemic level in developed and developing countries, interpretation of the increase in the prevalence of obesity needs to be undertaken. Genetic and environmental factors are among the causes of obesity. The contribution of genetic factors in the development of obesity is not very clear. Most of the research in this area has concluded that our genotype has not changed in the past thirty years (Hill and Melanson, 1999; Pescatello and VanHeest, 2000).

Many well-defined genetic factors can produce human obesity. Even if these are not the direct cause of obesity in some cases, still there is a genetic susceptibility (Bray, 1999). Bray (1999) listed at least 24 mendelian disorders in which obesity is a significant clinical characteristic; among this Prader-Willi syndrome is the best known. This is characterised by insatiable appetite, mental retardation, hypogonadism and strabismus. Fortunately these disorders rarely occur.

2.5. Health consequences of obesity

Obesity may lead to a number of health problems affecting many systems in the human body, as well as psychological and economical problems. Many studies present a direct association between weight, obesity and several diseases. These include type 2 diabetes mellitus, cardiovascular diseases (CVD), dyslipidemia, hypertension, gallbladder and respiratory diseases, cancer, female reproductive functions, osteoarthritis and gout (Bray, 2000). These studies include evidence of overweight or obesity in terms of BMI on body health as well as the effect of fat distribution in the body.

Health risks can be divided into two categories, mortality and morbidity. Life-insurance studies were the first to propose that obesity is a major risk factor in mortality, especially death from cardiovascular disease (Seagle *et al.* 2001). Most evidence suggests a J-shaped relationship between BMI and mortality rate, with the obese having the highest mortality risk. Allison *et al.* (1999) found that more than 80% of the estimated obesity-attributable deaths occurred among individuals with BMI >30 kg/m^2. Obesity is also associated with increased morbidity (Bray, 2000).

2.5.1. Diabetes Mellitus

Diabetes mellitus (DM) is a critical condition of chronic hyperglycaemia, normally associated with excessive thirst (polydipsia), increased urine volume, (polyuria), increased hunger (polyphagia) and weight loss. It is due to relative insulin deficiency or resistance, or both, and is an irreversible state. Chronic hyperglycaemia causes damage to the eyes (retinopathy), nerves (neuropathy), kidneys (nephropathy) and macro-vascular diseases, leading to heart and blood vessel problems (Ledingham and Warrell, 2000).

The diagnostic mark for DM has been based on blood glucose levels. In 1997, new recommendations for the classification and diagnosis of diabetes mellitus were agreed (Mayfield, 1998). This new classification named four types of diabetes mellitus, type1, type 2, other specific types and gestational diabetes (Table 2.11).

Table 2.11: Aetiologic classification of diabetes mellitus

Type 1 diabetes
• Immune-mediated
• Idiopathic
Type 2 diabetes
Other specific types
• Genetic defects of beta-cell function
• Genetic defects in insulin action
• Diseases of the exocrine pancreas
• Endocrinopathies
• Drug or chemical-induced
• Infections
• Uncommon forms of immune-mediated diabetes
• Other genetic syndromes sometimes associated with diabetes
Gestational diabetes

Source: Mayfield (1998)

The diagnostic criteria for DM depend on two of the following tests on different days.

- Fasting plasma glucose >126mg/dl (7.0mmol/L). Fasting is defined as no energy intake for at least 8 hours prior to the test.
- Casual plasma glucose >200mg/dl (11.1mmol/L). Casual is defined as any time of the day without regard to the time since the last meal.
- Two hour postprandial plasma glucose >200mg/dl (11.1mmol/L) during an Oral Glucose Tolerance Test (OGTT), using a glucose load containing the equivalent of 75 gm of anhydrous glucose dissolved in water.

Type 2 or non-insulin dependent diabetes mellitus (NIDDM) constitutes 85% of diabetic patients. The pathogenesis of type 2 is multifactorial involving both genetic and environmental factors. Genetic factors include defective pancreatic beta-cell function and abnormal insulin action in the target cell. Environmental influences include obesity, age, and lack of physical activity.

Obesity is found to be an important element in the later development of diabetes. The relationship between obesity and diabetes has been studied from different aspects including the influence of body weight in terms of BMI and fat distribution in the body, in particular abdominal fat (waist: hip ratio).

Several studies have shown the relationship between high BMI and the prevalence of diabetes in different age groups, sex and race. Colditz *et al.* (1990), in a cohort study of 113,861 US women aged 30-55 years during 8 years of follow-up, found an average BMI of 23-23.9kg/m^2; the relative risk of diabetes was 3.6 times that of women having a BMI less than 22kg/m^2. With an increase of 20-36 kg in body weight, the relative risk was 11.3 and with an increase of more than 35 kg the relative risk was 17.3.

Bonham and Brock (1985) studied the independent and interactive relationship of race, sex, obesity and age with the reported prevalence of NIDDM. They found that BMI had a stronger relationship with reported diabetes than race or sex, as shown in Table 2.12.

Table 2.12: Predicted percent of people with adult onset diabetes: United States, 1976

	Male BMI			Female BMI		
	< 24.38	26.51-28.48	≥28.49	<28.23	31.58-35.28	≥35.29
White						
20-44 years	0.5	0.6	1.5	0.5	1.0	3.2
45-54 years	2.9	4.0	7.3	1.8	3.5	8.8
55-64 years	4.2	5.9	8.6	2.5	5.1	10.1
≥65 years	6.8	8.4	9.5	5.3	9.3	13.9
Black						
20-44 years	0.7	0.8	3.6	0.6	1.0	3.7
45-54 years	5.0	4.6	8.1	4.9	7.0	9.2
55-64 years	6.3	8.7	13.4	4.4	9.4	11.1
≥65 years	8.3	15.4	25.0	3.9	11.6	14.9

Source: Bonham and Brock (1985)

In the San Antonio Heart Study (Wei *et al.* 1997), a cohort study of 721 Mexican American subjects aged 25-64 years and who were free of NIDDM, were followed for an average of 7.2 years. It was found that the risk of NIDDM for those of the highest quartile of waist circumference was 11 times greater than for the lowest quartile. The waist-NIDDM relationship was stronger in subjects with BMI $\leq 27 kg/m^2$ than in subjects with $> 27 kg/m^2$, which suggests that the distribution of body fat, especially the abdominal fat, is a more important determinant than total body fat.

2.5.2. Cardiovascular diseases (CVD)

CVD, including coronary heart disease and stroke, is the leading cause of death in the world (Anderson, 2001). Several behavioural risk factors, such as obesity, lack of exercise, hypertension and diabetes mellitus, are associated with the development of CVD. The prevalence of CVD is related significantly to the presence of hypertension and elevated blood lipids.

2.5.2.1. Blood lipids

Varied lipid/lipoprotein abnormalities have been noticed in obese individuals, including elevated total cholesterol, triglycerides (TG), lower high-density lipoprotein cholesterol (HDLC) and elevated low-density lipoprotein cholesterol (LDLC) (Després and Krauss, 1998). Hu *et al.* (2000) examined the relationship between obesity and lipoprotein profiles. They found that in women, BMI was significantly related to HDL cholesterol (r=-0.24), waist circumference was positively related to TG (r=0.14) and negatively related to HDL cholesterol (r=-0.23) while in men BMI was positively correlated with TG (r=0.3) and negatively correlated with HDL cholesterol(r=-0.35).

Borona *et al.* (1997) investigated the effect of obesity on cardiovascular risk factors. In 367 healthy subjects with normal glucose tolerance, TG and LDL cholesterol levels were significantly higher in obese compared with nonobese subjects: 1.5± 0.13 vs. 1.13± 0.08 mmol/L and 3.42± 0.25 vs. 2.27± 0.18 mmol/L respectively. In contrast, plasma HDL cholesterol levels were lower in obese compared with nonobese subjects: 1.27±0.04 vs. 1.46±0.06 mmol/L.

The effects of fat distribution on cardiovascular risk factors have been studied.

Caprio *et al.* (1996) studied the relationship between specific fat depots early in the course of obesity and cardiovascular risk factors. It was found that total cholesterol, TG and LDL cholesterol were significantly higher in obese compared with nonobese adolescent girls. In addition, visceral fat was positively correlated with triacylglcerol (r = 0.53) and negatively correlated with HDL cholesterol (r = -0.54).

2.5.2.2. Hypertension

Hypertension is an increase of blood pressure in the arteries continuing over a period of time. The World Health Organisation (WHO) defines blood pressure of 160/90 mmHg as hypertensive (Ledingham and Warrell, 2000). The systolic pressure measures the blood pressure in the arteries when the heart is contracting and pumping blood, while diastolic pressure measures the blood pressure in the arteries when the heart is at rest.

Recent guidelines for classification of blood pressure for adults aged 18 years and older (Mertens and Van Gaal, 2000) are presented in Table 2.13.

Table 2.13: Classification of blood pressure for adults aged 18 years and older

Category	Systolic (mmHg)		Diastolic (mmHg)
Optimal	< 120	and	<80
Normal	<130	and	<85
High normal	130-139	or	85-89
Hypertension			
Stage 1	140-159	or	90-99
Stage 2	160-179	or	100-109
Stage 3	≥ 180	or	≥110

Source: Mertens and Van Gaal (2000)

Hypertension can be either primary (essential hypertension) or secondary. Ninety-five percent of all cases of hypertension are essential hypertension, which is defined as high blood pressure with no apparent cause (Ledingham and Warrell, 2000). However, there is a group of factors associated with the development of essential hypertension including: genetic (e.g. family history); sex and age - males between 35-50, and females past menopause are at greater risk; too much salt in the diet; life style

pattern such as smoking and sedentary lifestyle; and weight - more than 20% of the ideal body weight.

The correlation between obesity and hypertension has been observed in many societies. He *et al.* (2000) studied the association between obesity and blood pressure in pre-school Chinese children aged 0.1-6.9 years. They found that an increase of 1 BMI unit was associated with, on average, an increase of 0.56 mmHg and 0.54 mmHg in systolic and diastolic blood pressure respectively in obese children.

Gilbert *et a*l. (1996) assessed the relationship between blood pressure and anthropometric measurements in a sample of Navajo adolescents. The prevalence of high- normal blood pressure among obese adolescents (BMI 90^{th} and 95^{th} percentile) was 9% for boys and 9% for girls, nearly twice that expected.

Harris *et al.* (2000) examined the association between hypertension, obesity, and fat distribution among African-American and white men and women. They found that the prevalence of hypertension was greater in African-American than whites in both genders (55% African-American men vs 29% white men and 56% African women vs 26% white women). Men and women with hypertension had larger mean values for BMI, waist circumference, and WHR than non-hypertensive women and men as shown in Table 2.14.

Table 2.14: BMI, waist circumference and WHR for African-American (AA) and white women and men (mean±SD)

	Women				Men			
	No hypertension		Hypertension		No hypertension		Hypertension	
	AA	White	AA	White	AA	White	AA	White
BMI	29.7±5.9	25.9±4.9	31.8±6.7	29.1±6.1	26.8±4.3	27.0±3.7	28.5±5.1	28.0±4
Waist (cm)	96.9 ±15.3	90.9 ±13.6	103.4 ±16.3	100.4 ±15.8	94.0 ±12.0	98.4 ±9.8	99.6 ±13.0	102.0 ±11.0
WHR	0.89±0.08	0.88±0.08	0.92±0.08	0.93±0.08	0.93±0.06	0.96±0.05	0.95±0.05	0.90±0.0

Source: Harris *et al.* (2000)

2.5.4. Cancer

Overweight and obesity have been observed to have an association with cancer, especially colo-rectal and prostate cancer in males and reproductive and gallbladder cancers in females (Bray, 2000).

Colon cancer is considered second only to lung cancer as a cause of cancer death and many environmental and lifestyle factors, such as diet, physical activities and overweight, have been implicated in the carcinogenesis of the colon (Shike, 1996).

Ford (1999) studied the association between obesity and colon cancer in a nationally representative cohort of men and women aged 25-74 years. Among 13,420 subjects, 222 cases of colon cancer were identified. The results showed that when comparing subjects with BMI <22kg/m^2 with those who have BMI of 22-<24, 24-<26, 26-<28, 28-<30 and ≥30kg/m^2 the hazard ratios were 1.79, 1.86, 2.47, 3.72, and 2.79 respectively.

The risk of breast cancer has also been investigated in relation to BMI and central adiposity. Higher BMI has been associated with a lower risk of cancer before menopause and with an increased risk of cancer after menopause (Huang *et al.* 1999).

Peacock *et al.* (1999) supported the previous study that increased body size decreased the risk of breast cancer among premenopausal or young women. They suggested that obese women in their childbearing years can create amenorrhoea or inconsistent menstrual periods by shortening the luteal phase of the cycle, which is when progesterone is produced and mitosis occurs. This reduction in progesterone decreases the degree of breast cell mitosis, thereby producing a protective effect against breast cancer.

2.5.5. Female reproductive functions

Obesity is an important risk factor in obstetrics and gynaecology. It affects female reproductive function in several aspects, including menstrual abnormalities and infertility. In addition, obese women may experience more problems during pregnancy with an increased frequency of toxaemia and hypertension (Blumenkrantz, 2000).

One of the most common gynaecological problems connected with obesity is polycystic ovary syndrome (PCOS). This syndrome can affect women between late

adolescence and the menopause. Patients may present with oligomenorrhoea or amenorrhoea, anovulation or infertility, hirsutism or acne due to an association between obesity and hormonal imbalances (Hartz *et al.* 1979). Women with PCOS have at least seven times the risk of myocardial infarction and ischaemic disease of other women and may develop type 2 diabetes mellitus after the age of 40 years (Kidson, 1998).

Few studies have studied the effect of excess weight on infertility. Bolumar *et al.* (2000) studied the effect of BMI on delayed pregnancy as a part of a European Study on Infertility and Subfecundity. The study showed a strong link between increased BMI and delayed conception. Thirty-one percent of women who had BMI ≥ 30 became pregnant after ≥9.5 months while 18% of women who had BMI between 20-24.9 became pregnant after the same period (delayed conception was defined as a time to pregnancy that exceeded 9.5 months of unprotected intercourse).

Grodstein *et al.* (1994) examined the association between BMI and infertility. Women with BMI ≥ 27 had a relative risk of ovulatory infertility of 3.1 compared with non-obese women with BMI 20-24.9. In addition, Lake *et al.* (1997) found that obesity at age 23 years and 7 years both independently increased the risk of menstrual problems by the age of 33 years. Obesity at 23 years increased the risk of hypertension in pregnancy; also obese women at 23 years were less likely to conceive within 12 months of unprotected intercourse.

2.5.6. Gallbladder diseases

The main cause of disease of the gallbladder is gallstones (cholelithiasis). Gallstones can be divided into 2 types, those composed of cholesterol and those composed of bile pigment. The first type is the most prevalent (Ledingham and Warrell, 2000).

The definite risk factors for gallstones include obesity, sex (females more than males), age (over 40 years), diet (high in animal fat) and rapid weight loss. A possible explanation is that all the above risk factors are accompanied by increases in cholesterol secretion.

The Nurses Health Study (Stampfer *et al.* 1992) found that women with a BMI

> 45kg/m^2 had a sevenfold excess risk compared with those who have BMI < 24kg/m^2. Women with a BMI > 30kg/m^2 had a yearly gallstone incidence of >1% compared with those with a BMI ≥ 45kg/m^2 who had a yearly gallstone incidence of ≈ 2%/year.

2.5.7. Osteoarthritis (OA)

Osteoarthritis is a disease process of synovial joints characterised by focal areas of loss of hyaline articular cartilage, associated with increased activity in marginal and subchondral bone (Kumar and Clark, 1998). Obesity is an important risk factor for osteoarthritis of the knees and has weak associations with hip and hand disease. The most rational explanation for the effect of weight in developing OA is that overweight increases the load across a joint, which increases the stress of cartilage and induces a breakdown that then leads to OA (Felson, 1996).

In a study of women aged 48-70 years, it was estimated that an increase of one kilogram in body weight was associated with significant increases of 9-13% in the risk of OA (Cicuttini *et al.* 1996).

2.5.8. Respiratory functions

It has been suggested that obesity, in particular gross obesity, has a harmful effect on respiratory function. Obstructive Sleep Apnoea (OSA) or Pickwickian Syndrome is the most common problem and is associated with upper body obesity (Strohl *et al.* 1998). It is defined as an absence of breathing during sleep and is characterised by loud snoring and partial or complete obstruction of the upper air - way during sleep for up to one minute at a time. During this period, heart rhythms may become very irregular, which may lead to a fatal heart attack.

In a cohort study, Young *et al.* (1993), studied a random sample of 602 employed men and women, aged 30-60 years, by overnight polysomnography to determine the frequency of apnoea and hypoapnoea during sleeping. The prevalence of sleep-disordered breathing was 9% for women and 24% for men and male sex and obesity were strongly associated with the presence of sleep-disordered breathing.

2.5.9. Psychosocial problems

In the past, increased body weight was considered a symbol of wealth in countries. With the increase in the prevalence of obesity worldwide and the diseases associated with obesity, such as type 2 diabetes mellitus, hypertension and CVD, this idea has vanished.

Nowadays, obese people may suffer many problems related to their increased body weight. These include discrimination in many places, such as school, colleges, work places, health care centres and shopping centres (Bray, 2000). Opportunities of marriage have been found to decrease, as have household incomes (Gortmaker *et al.* 1993).

In general, increased adiposity has been associated with decreased quality of life, which may lead to depression and emotional distress due to discrimination (Williamson and O'Neil, 1998).

2.6. Economical costs

The economic cost of obesity to a community and individual can be direct or indirect. Direct costs include the cost of personal health care, hospital care, health care team and drugs. Indirect costs include lost output due to workdays lost and excess sick days caused by morbidity.

The direct cost of obesity has been estimated in many counties as a percentage of the total sick care costs. These estimates suggest that between 2-8% of the total sick care costs are due to obesity (Donald, 2000), as shown in Table 2.15.

Table 2.15: Direct costs of obesity in Western countries

Reference	Country	Year	Costs $ billion	Definition of obesity (BMI)	Conditions included
Birmingham *et al.* (1999)	Canada	1997	1.8	>27	Type 2 DM, hypertension, CVD
Colditz (1999)	USA	1995	70	30	Type 2 DM, hypertension, gallbladder, cancer (breast endometrium, colon), OA
Levy *et al.* (1995)	France	1992	1.7	≥27	Hypertension and cancer
Colditz (1992)	USA	1986	39.3	Females >27.3 Males >27.8	Type 2 DM, hypertension, CVD, gallbladder, postmenopausal breast cancer

The direct health cost of obesity in the US almost doubled between 1986-1995 as the prevalence of obesity increased to 22.4% and formed 7% of the total health care cost. In Canada and France it formed 2.4% and 2% respectively.

The indirect cost of obesity, such as lost productivity, days of restricted activity and days in bed, was evaluated by Wolf and Colditz (1996). The average marginal number of work loss days, excess restricted activity days and excess bed days of patients with BMI 25-29 and ≥30kg/m^2 compared with patients who have BMI < 23kg/m^2 are shown in Table 2.16.

Table 2.16: Indirect cost indexes within three BMI categories compared with lean individuals

	BMI kg/m^2		
	23-24.9	25-29	≥30
Excess work-loss days/ person	-0.02	0.42	1.07
Excess restricted activity days/ person	-0.63	0.703	7.2
Excess bed days/person	-1.49	-0.52	2.87

Source: Wolf and Colditz (1996)

Patients with BMI 25-29 and ≥ 30kg/m^2 had higher excess work loss days (0.42 and 1.07 respectively) compared with patients with BMI <23kg/m^2. Also they have excess restricted activity days of 0.703 and 7.2 respectively.

2.7. Prevention and treatment of obesity

2.7.1 Prevention of Obesity

The increase in the prevalence of overweight and obesity worldwide is a major economic and health problem. Therefore, the prevention of obesity is an important issue. The prevention of obesity includes two main objectives. Firstly, prevention of overweight or obesity itself. Secondly, prevention or avoidance of weight regain following weight loss, and prevention of further weight gain in obese people who are unable to lose weight (National Heart, Lung, and Blood Institute, 1998).

In view of this, the causes of obesity are of concern. As mentioned in section 2.4, environmental factors, such as food intake and physical activities, play the most important role in the cause of obesity. Therefore, efforts should be concentrated on the causes of high food intake and low physical activities.

2.7.2. Treatment of obesity

Treatment of obesity aims to:

(1) decrease the morbidity of some diseases due to the association between those diseases and obesity, such as diabetes mellitus (Colditz *et al.* 1990), hypertension (He *et al.* 2000), and colon cancer (Ford, 1999).

(2) help control some diseases worsened by obesity, such as hypertension (Davis *et al.* 1993) and diabetes mellitus (Agurs-Collins *et al.* 1997).

(3) decrease the cost of medications used for these diseases (Collins and Anderson, 1995).

(4) improve the overall psychological matters resulting from being obese.

Many methods are used to treat obesity, some of which are a combination of methods. The following are the most frequent methods used.

2.7.2.1. Dietary therapy

Many different diets are used for weight loss, such as low calorie diets (LCDs), very low calorie diets (VLCDs), and low fat diets. LCDs provide approximately 1000-1500 Kcal/ day and provide weight loss by an average of 8% over 3-12 months (National Heart, Lung, and Blood Institute, 1998).

The VLDLs diets cause rapid weight loss as they are severely limited in energy intake 1.2-2.5MJ (300-600 kcal/ day) (Pi-Sunyer, 1992) and achieve around 20 kg weight loss in 12 weeks (Wadden *et al.* 1983).

In low fat diets, the percentage of fat can range from 20-30% of total energy intake (National Heart, Lung, and Blood Institute, 1998) and promote a weight loss by producing a reduced energy intake.

2.7.2.2. Physical activity

It is well known that physical activity increases energy expenditure. However, exercise alone is not an efficient method to achieve weight reduction. Obese people are encouraged to practice exercise for at least 30 minutes for five days a week (Garrow, 2000).

2.7.2.3. Surgical

Surgery is an approach to treat obesity in severe cases (BMI> 40). Different procedures are used: some aim to reduce the size of the stomach as well as the amount of food intake (Whitney *et al.* 1998), while others aim to cut or suck fat from subcutaneous sites, although it may have little effect on body weight (Whitney *et al.* 1998). Jaw wiring is also a procedure that aims to force the patient to consume a liquid diet, however weight gain tends to occur immediately after the wires are removed (Garrow, 2000).

2.7.2.4. Pharmacotherapy

Many types of drugs are used to treat obesity, such as appetite suppressants, diuretics; drugs to speed up energy metabolism, thyroxin and laxatives (Whitney *et al.* 1998). However, anti-obesity drugs are not recommended in the treatment of obesity in

children, pregnant and lactating women (The International Diabetes Institute, 2000).

2.7.2.5. Behavioural therapy

Behavioural therapy represents those approaches that provide tools for removing obstacles to compliance with dietary therapy and/or increased physical activity. It aims to change hundreds of small behaviours in our lifestyle. Whitney *et al.* (1998) described three different behavioural modification strategies to weight loss:

(1) to eliminate inappropriate eating clues, such as shopping when not hungry, serve low-fat meals and shop from a list.

(2) to suppress the clues you cannot eliminate, such as eating only in one place, clear plates directly into the garbage, and serving foods on small plates.

(3) to strengthen the clues to appropriate eating and exercise, such as keeping the favourite foods in the front of the refrigerator.

2.7.3. Primary weight loss plan

It is necessary to define the background factors of the obese patients before implementation of a weight loss plan. The weight loss plan should contain the following aspects:

1. Reasonable weight loss goal: a rate of 1-4 lb/month for children (Moran, 1999) and 0.5-1.0 kg/week for adults (Garrow, 2000).
2. Dietary management: provide adequate amount of energy, more than 4.2 MJ per day (Garrow, 2000), and recommended percentage of carbohydrate, protein and fat.
3. Physical activity: it is necessary to maintain weight loss and to redistribute body fat into muscle. The recommended goal is 20-30 minutes of physical activity per day for children (Moran, 1999) and at least 30 minutes of brisk walking five times a week for adults (Garrow, 2000).
4. Behavioural modification: self-monitoring, nutrition education, modification of eating habits and physical activity.
5. Family support: involvement of family and friends in the implementation of the

weight loss plan is essential to achieve the goals.

2.8. Summary

This review has concentrated on what is obesity, the prevalence, the aetiology, the health and economical cost and prevention and treatment of obesity.

Obesity is an increasing problem in developed and developing countries, among different age groups. The review has concentrated on the main causes of obesity, which appear to be environmental more than genetic. The increased reliance on technology and labour-saving devices has reduced the need for everyday activities. In addition, the increased reliance on high-fat foods, energy dense foods, and fast foods deteriorate the energy balance equation and as a result of that the prevalence of obesity is increasing.

The overall efforts should concentrate on behaviours to decrease the prevalence of obesity, especially among the young generations (children and adolescents). Cooperation and the involvement of families, schools, food industry and mass media is necessary to decrease the prevalence of obesity especially in children and adolescents.

CHAPTER THREE: SUBJECTS AND METHOD

The study reported in this thesis is divided into three parts:

(1) Estimation of the prevalence of overweight, obesity and the growth patterns of schoolgirls aged 10-19 years in the UAE.

(2) Assessment of food/energy intake and physical activity of schoolgirls aged 10-19 years in the UAE.

(3) The effect of menstrual cycle on macronutrient and energy intake and energy balance in a group of women aged 19-28 years.

For completeness and clarity, the subject description and methods used in the study are all assembled in this chapter.

3.1. Subject selection and recruitment

This study took place in the United Arab Emirates between October 1998 and April 1999 and was conducted in five Emirates, Abu Dhabi, Al Sharjah, Dubai, Ras Al Khaimah and Al Fujairah. These five Emirates represent the highest residence of population in the UAE (section 1.3).

Sixteen female-only governmental schools participated in this study. Three types of schools were identified: primary, preparatory and secondary. Primary schools cover the school years from 1-6, preparatory covers the school years from 7-9 and secondary covers 10-12 school years. It was impossible to select the schools at random due to social and practical limitations. Rather, the most important criteria in choosing the participating schools were: (1) their willingness to participate in the study; (2) the agreement of the school administrators to release the students for one session to carry out the anthropometric measurement; (3) their willingness to complete the questionnaire. Another criterion for consideration was the population density of each Emirate and the distribution of schools in different Emirates. Some of the schools refused to participate in the study, especially students in the 12^{th} school year because at the end of the year they sat the general exam.

A total number of 898-schoolgirls aged 10-19 years were recruited from the 6^{th} to the 12^{th} year. The distribution of the sample by Emirates and school year is shown in table 3.1.

Ethical approval for this study was obtained from the Ministry of Health in the UAE Appendix 3.1.

Table 3.1: Distribution of sample by Emirates and school year

Emirates	School year							All grades	
	6	7	8	9	10	11	12	N	%
Abu Dhabi	61*	89	43	49	61	65	20*	388	43
Sharjah	46	26	3	2	38	22	35	172	19
Dubai	9	0	5	63	25	21	23	146	16
Ras al-Khaimah	0	25	86	4	5	23	2	145	16
Fujairah	0	0	2	22	21	0	2	47	5
Total	116	140	139	140	150	131	82	898	

* Columns and rows show the number of girls in each school year.

3.2. Anthropometric measurements

Anthropometric measurements are one of the main methods used to assess the nutritional status of populations (Gibson, 1990). In this study weight, height, mid-upper-arm circumference, and triceps skinfold thickness were measured. These measurements are simple and inexpensive to make. Due to cultural restrictions, it was not possible to take other measurements such as subscapular and suprailiac skinfold thickness or waist and hip circumferences. Indeed, the subjects were reluctant to even expose parts of their arms. In all these measurements, measurement error and intra-individual error was normally less than 1%.

3.2.1. Body Weight

Weight was measured using a calibrated scale to ±0.1 kg. The subject was asked to stand erect, wearing her school uniform and without shoes, in the centre of the platform. Weight was recorded to the nearest 0.1kg (Gibson, 1990). Reference values from the National Centre for Health Statistics in collaboration with the National Centre for Chronic Disease Prevention and Health Promotion 2000 (Centres for Disease Control and Prevention, 2000) were used. Weight was divided into five percentile categories as follows: $<5^{th}$, 5^{th}-$<25^{th}$, 25^{th}-$<75^{th}$, 75^{th}-90^{th} and $>90^{th}$.

3.2.2. Height

Height was measured using a portable stadiometer (specially designed in the UAE). The subject stood perfectly straight, with her arms relaxed by her sides and her ankles and knees together. The subject's head was positioned in the Frankfurt Plane (Cameron, 1984). The height was recorded to the nearest 0.5 cm. Reference values from the National Centre for Health Statistics in collaboration with the National Centre for Chronic Disease Prevention and Health Promotion 2000 (Centres for Disease Control and Prevention, 2000) were used. Height was divided into five percentile categories as follows: $<5^{th}$, 5^{th}-$<25^{th}$, 25^{th}-$<75^{th}$, 75^{th}-90^{th} and $>90^{th}$.

The Body Mass Index (BMI) was calculated from the measurement of height and weight as follows:

BMI = Weight (kg)/ Height $(m)^2$.

Reference values from the National Centre for Health Statistics in collaboration with the National Centre for Chronic Disease Prevention and Health Promotion 2000 (Centres for Disease Control and Prevention, 2000) were used. The cut-off value for overweight was between $\geq 85^{th}$ and $< 95^{th}$ percentile, and $\geq 95^{th}$ percentile for obesity (Must *et al.* 1991).

3.2.3. Skinfold thickness

Skinfold thickness measurements are used to estimate the percentage of total body fat. A Lange Skinfold Calliper (Beta Technology Inc. CA.USA) was used to measure skinfold thickness. Four sites are usually measured to calculate the percentage of total body fat, namely triceps, biceps, subscapular and suprailiac. In this study, triceps only were measured due to cultural restrictions. Three measurements were taken and the average value was recorded in millimetres.

Triceps skinfold thickness (TSF) was measured at the mid-point of the upper non-dominant arm. A fold of skin and underlying fat was grasped by the forefinger and the thumb, 1 cm above the marked mid-point. The jaws of the calliper were applied at the marked point and a reading was taken within 2-3 seconds (Cameron 1984).

The reference values for TSF were taken from the first National Health and Nutrition Examination Survey NHANES I (1971-1974) (Gibson, 1990). Triceps skinfold was divided into five percentile categories as follows: $<5^{th}$, 5^{th}-$<25^{th}$, 25^{th}-$<75^{th}$, 75^{th}-90^{th} and $>90^{th}$.

3.2.4. Mid-Upper-Arm Circumference (MUAC)

A tape was used to measure the MUAC. The non-dominant arm was used for the measurement with the arm bent at a 90° angle. The measurement was taken at the mid-point between the acromion process on the shoulder blade and the tip of the olecranon of the ulna (Cameron 1984). The tape was wrapped around the mid-point location gently and the measurement was recorded to the nearest 0.1 cm.

The reference values for MUAC were taken from the first National Health and Nutrition Examination Survey NHANES I (1971-1974) (Gibson, 1990). MUAC was divided in to five percentile categories as follows: $<5^{th}$, 5^{th}-$<25^{th}$, 25^{th}-$<75^{th}$, 75^{th}-90^{th} and $>90^{th}$.

Mid-upper-arm muscle circumference (MUAMC) was calculated from the measurement of the MUAC and TSF as follows (Gibson 1990):

MUAMC = MUAC (mm)- π TSF (mm)

The reference values for MUAMC were taken from the first National Health and Nutrition Examination Survey NHANES I (1971-1974) (Gibson, 1990). MUAMC was divided in to five percentile categories as follows: $<5^{th}$, 5^{th}-$<25^{th}$, 25^{th}-$<75^{th}$, 75^{th}-90^{th} and $>90^{th}$.

3.3. Questionnaire

A questionnaire was used to collect socio-demographic data, family history of diseases, such as diabetes mellitus and hypertension, and the lifestyle patterns of the subjects (Appendix 3.2). The questionnaire was made up of four parts.

1. General information, such as date of birth, nationality, education and occupation of parents, the ownership of car and the availability of housemaid.
2. Dietary information, including the frequency of consumption of the main meal, and consumption of snacks.

3. Health information concerning the subjects and their parents. The time of menarche was also recorded.
4. Lifestyle patterns, including television viewing, physical activity, and participation in housework.

3.4. Food and energy intake estimation

A small number of subjects (76) was chosen for this part of study in order to maximize compliance and the ability to complete the study within the given time limitations.

Seventy-six subjects out of the whole sample participated in this part of the study. The sample was chosen from two schools in Al-Ain city (belonging to Emirate of Abu Dhabi): Al-Ain secondary school for girls and Atika preparatory school for girls.

The criterion for choosing these two schools was the willingness of the staff and students to participate in this study. Forty-one subjects completed all aspects of this study. The purpose of this study was to investigate the food habits, meal patterns, and energy and micronutrient intake of the subjects.

3.4.1. Energy and nutrients intake

Food frequency questionnaire (FFQ) and three day estimated food records were used to study the food habits, energy and macronutrient intakes in the UAE female adolescents. These methods were chosen because of simplicity, practicality and fewer burdens on subjects. This is the first such study in the UAE.

3.4.1.1. Food frequency questionnaire

A semi-quantitative FFQ was used in this study. The food items listed were considered to be representative of the range of foods commonly used in the UAE.
The FFQ included 59 food items, divided into seven food groups:

(1) Bread and cereals (10 items)

(2) Vegetables; fruits and fruit juice (17 items)

(3) Meat and meat alternatives (9 items)

(4) Milk and milk products (7 items)

(5) Fat, oil and nuts (4 items)

(6) Beverages (6 items)

(7) Sweets (6 items)

Two types of bread were known to be traditional bread in the UAE (*Rgag* and *Cho-bab*). The vegetables and fruit section included two groups of vegetables (dark green leafy vegetables and root vegetables). In addition, 12 types of fruit, plus fruit juice, were assessed. Legumes were included in the meat and meat alternatives group.

The FFQ was adapted from the Harvard University Food Frequency Questionnaire (Willett, 1990). For each food item, a specified portion size was given using commonly used units, such as one-fourth loaf of Arabic white bread or one cup (240 ml glass) of milk. In the present study, subjects were asked how often, on average, they had consumed each food during the last month.

The frequency response was divided into nine categories:

(1) Almost never

(2) 1-3 times per month;

(3) Once per week;

(4) 2-4 times per week;

(5) 5-6 times per week;

(6) Once per day;

(7) 2-3 times per day;

(8) 4-5 times per day;

(9) Six or more times per day.

For the purpose of analysis, the frequency response was re-classified into four categories: (1) almost never; (2) monthly; (3) weekly; and (4) daily (Appendix 3.3). The number and percentage of food items consumed were calculated according to the four categories of frequency response.

3.4.1.2. Estimated food records

Subjects were asked to describe on a record sheet all foods and drinks consumed each day, emphasizing the day of the week, the name of food items, the amount using household measures and the method of preparation (Appendix 3.4)

The subjects were asked to record their food/drink intake immediately after consumption on the provided record sheet. Subjects were asked to record their intake for three days (two school days and one weekend day).

Three sessions were held for the subjects before starting the study. The recording procedure, the definition of the portion size of the most common foods consumed in the UAE, and the detailed description of types and quantities of the foods were demonstrated in these sessions.

After the completion of the food diaries, household measures and commonly used units, such as one-fourth loaf of Arabic bread, were translated to grams. The amount of each food item eaten was entered into a dietary analysis computer program.

Results for four nutrients were determined: energy, protein, fat, and carbohydrate. Intakes for each day were calculated using the DIET5 for Windows dietary analysis computer program (The Robert Gordon University, Aberdeen). In addition, the Arabic and traditional foods were analysed using a book containing the nutrient content of many foods used in the Arab and Gulf countries (Musaiger, 1995). An example of the printout is shown in Appendix 3.5.

3.5. Physical activity

Seventy-six subjects out of the whole sample participated in this part of the study. The sample was chosen from two schools in Al-Ain city (belonging to Emirate of Abu Dhabi): Al-Ain secondary school for girls and Atika preparatory school for girls.

The criterion for choosing these two schools was the willingness of the staff and students to participate in this study. Forty-one subjects completed all aspects of this study. Food intake and physical activity were both measured in these subjects. The purpose of this study was to estimate the level of physical activity of the subjects.

Physical activity diary records were kept for three days, including two schooldays and one weekend day. A modified method originally described by Bouchard *et al.* (1983) was used. Students were ask to record the dominant activity they had carried out every 15 minutes on a record sheet which was divided into 96 periods for each day (1440 minutes) (Appendix 3.6).

In the Bouchard *et al.* (1983) method, activities were categorized into nine categories, 1 indicated sleeping and 9 indicated intense manual work. The subjects chose the number that best described the type of exercise they did. However, it was not appropriate to follow the same approach of Bouchard *et al.* (1983) as it was considered difficult for the subjects to judge to which category their physical activity belonged. Instead they were asked to write the type of physical activity on the record sheet in the appropriate square.

The subjects were given a detailed explanation and demonstration of the activity diary, the purpose and the method. Subjects were encouraged to contact the researcher by telephone if they had any difficulties in recording their activities.

The physical activity diaries were analysed using DIET5 for Windows computer program (The Robert Gordon University, Aberdeen). In this program, age, weight, and the gender of the subject was specified. Each row formed an hour and was divided into 12 digits; each digit illustrated 5-minutes and in each digit a number from 1-8 was typed. The physical activity level (PAL) was calculated.

The researcher carried out the classification of the physical activities. The levels of physical activities are shown in Table 3.2. An example of the printout is shown in Appendix 3.7.

The physical activities that the subjects participated in were also classified as follows:

1. Seated activities: watching television, using computer and other television games, reading, doing homework, and using the telephone.
2. Sleeping: during the night and day.
3. Household activities: participation in household work, such as vacuuming, dishwashing, dusting, ironing, and washing clothes.
4. Other activities: ablution, praying, showers, and shopping.

The number of hours spent in each category was calculated and the mean value was recorded.

Table 3.2: Levels of physical activity

	Physical Activity Ratio (PAR)	Description of Physical Activity
1	1.0	Sleeping.
2	1.2 (1.0-1.4)	Lying, sitting, watching television or listening to radio.
3	1.6 (1.5-1.8)	Sewing, knitting, washing dishes and ironing.
4	2.1 (1.9-2.4)	Dusting and cleaning, washing small clothes.
5	2.8 (2.5-3.3)	Dressing and undressing, showering, vacuuming and walking slowly.
6	3.7 (3.4-4.4)	Mopping the floor, gardening and walking at a medium pace.
7	4.8 (4.5-5.9)	Polishing furniture, walking fast and digging.
8	6.9 (6.0-7.9)	Walking uphill with a load, jogging, and cycling.

Physical activity ratio (PAR) is defined as the actual energy cost of an activity, minute by minute. It is calculated as follows (James and Schofield, 1990):

$$\frac{\text{the energy cost of an activity per minute}}{\text{the energy cost of the basal metabolic rate per minute}}$$

In order to calculate PAL values from individual PAR values the following calculation is shown illustratively:

Example:

1. No. of hours spent in sitting and watching television equals 9.0
2. PAR value for sitting equals 1.2
3. Fraction of time spent in sitting out of 24 hours equals 9/24 = 0.38
4. PAL = PAR x fraction = 0.45.

The following example illustrates the method of calculating PAL from PAR values in one of the subjects (data taken from Appendix 3.7).

Activity	Number of hours	PAR	PAL
In bed	10.0	1.0	10.0/24 * 1 = 0.42
Sitting, watching television and computer	9.0	1.2	9.0/24 * 1.2 = 0.45
Dish washing and standing	2.5	1.6	2.5/24 * 1.6 = 0.17
Dusting and hair dressing	0.5	2.1	0.5/24 * 2.1 = 0.04
Praying, showering and dressing	2.0	2.8	2.0/24 * 2.8 = 0.23
Total	24.0		1.31

3.6. Energy balance

3.6.1. Prediction of BMR

Estimates of basal metabolic rate (BMR) were calculated from standard formulas based on height, weight and age. The formula used for females aged 10-18 years was FAO/WHO/UNU (1985). Whilst the equations from Henry *et al.* (1999a) are more applicable to the prepubertal period, it was decided to use the FAO/WHO/UNU equations due to their wider age band:

FAO/WHO/UNU (1985):

BMR (MJ)= 0.0510 W+ 3.12

Where W= weight (kg)

3.6.2. Estimation of energy expenditure

The factorial method was used for the calculation of daily energy expenditure. As the major components of energy expenditure are BMR and physical activity, the equation was expressed as:

TEE = BMR X physical activity level (PAL)

Using data from one of the study subjects, an example of the calculation is shown

below.

Subject 10

Age: 12 years

Weight: 40.6 kg

BMR (FAO/WHO/UNU)= 5191 kJ

PAL = 1.31

TEE = 5191 X 1.31 = 6800 kJ

3.7. Statistical analysis

Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS 10.05; SPSS Inc, Chicago, IL, USA, 1999). Means and standard deviations (SD) were calculated. Macronutrient intakes were expressed as a percentage of total energy intake. Prior to statistical analysis, the normality of the data was tested using the Kolmogorov-Smirnov statistic with a Lilliefors significance level.

Anthropometric measurements were compared with reference values using the one sample t-test. Pearson's correlation coefficient was used to assess the association between BMI and MUAC and MUAMC. The independent sample t-test was used to assess differences between the two age groups (11-14 yrs and 15-17 yrs). Comparisons between schooldays and the weekend were assessed using the paired t-test.

Levels of inter- and intra-individual variation of BMR and energy intake were assessed by determining the coefficient of variation (CV). Paired t-tests were used to see if there were significant differences in BMR, EI and macronutrient intake between the follicular and luteal phases of the menstrual cycle.

Statistical significance was set at $P < 0.05$.

CHAPTER FOUR: DEMOGRAPHY AND LIFESTYLE PATTERNS IN THE UAE

The United Arab Emirates (UAE) is a federation consisting of two groups of population, locals and nonlocals (expatriates). The vast increase in wealth as a result of oil discovery has had major impact on demographic structure and lifestyle patterns.

4.1. Demographic profile

The demographic characteristics of the sample are presented in Table 4.1. The total number of subjects enrolled in this study was 898 schoolgirls. The age of the subjects ranged from 10-19 years. Seventy–eight percent of the sample was Emirati citizens; the remaining 22% were mainly from Egypt, Jordan, Syria, and Sudan (Table 4.1).

4.2. Family characteristics

The percentage of mothers who were illiterate was 27% compared to 15% of fathers. It is noticeable that illiteracy is high among females because following the formation of federation in 1971, formal schools were established and the majority of students were boys (Section 1.7). Eighty-four percent of fathers and 12% of mothers were employed because men still remain the breadwinners. The family size of the majority of the sample (62%) ranged from 5-10 members. The ownership of private cars was high among the subjects' families (95%); 32% owned one car and 23% owned more than three cars. The greater availability of cars at home negatively affects lifestyle, by reducing the daily physical activities of the children and their families.

The availability of a housemaid was 65% of the sample, of which 55% had one housemaid (Table 4.1). The availability of housemaids affects the lifestyle in different aspects:

(1) high dependence on housemaids in child rearing which affects the lifestyle in early childhood.

(2) high dependence on housemaids influences the dietary food habits of the community, because they are responsible for meal preparation. As the majority

of housemaids are expatriates, they will prepare their own dishes.

(3) high dependence on housemaids may decrease the physical activities of females, especially the household work (Table 6.13).

A combination of these factors may increase the prevalence of obesity in the UAE – a point that will be expanded later.

Table 4.1: Subject profile

Characteristics	Percentage
Nationality	
Emirati	78
Non- Emirati	22
Educational level of mother	
Illiterate	27
Read and write	18
Elementary	17
Preparatory	11
Secondary	14
Higher education	13
Educational level of father	
Illiterate	15
Read and write	19
Elementary	11
Preparatory	13
Secondary	16
Higher education	26
Employment	
Mother: Employed	12
Unemployed	88
Father: Employed	84
Unemployed	16
Family size	
< 5	10
5-10	62
11-15	25
>15	3
Ownership of car	
No	5
Yes	95
Number of cars	
One	32
Two	26
Three	19
> Three	23
Availability of housemaid.	
No	35
Yes	65
Number of housemaids.	
One	55
Two	26
Three	12
> Three	7

4.3. Dietary habits

4.3.1. Main meals

Food habits were characterized by irregular meal patterns. Many adolescents skipped breakfast. In this study, 39% of the subjects ate breakfast on a daily basis, while 1% and 4 % skipped lunch and dinner respectively (Figure 4.1). Musaiger and Gregory (1992) found that 37% of intermediate girls skipped their breakfast and 33% ate it frequently. The results in this study are consistent with these findings. The consumption of lunch was high as this represents the main meal in this region as well as in the rest of Arab countries.

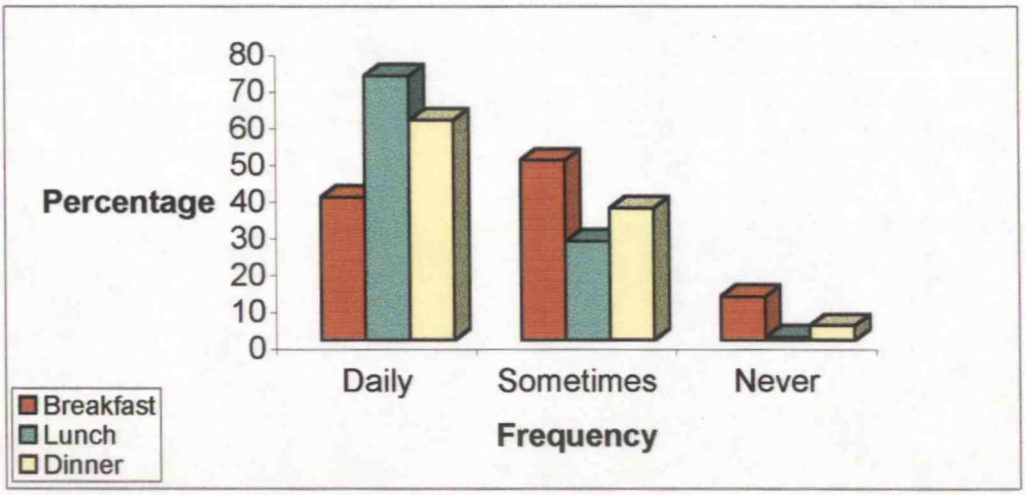

Figure 4.1: Percentage of subjects having breakfast, lunch, and dinner daily, sometimes and never.

4.3.2. Snacking

Eating between meals has become a part of modern lifestyle especially while watching television (Coon *et al.* 2001). Snacking was frequent among the subjects of this study. Ninety-five percent of the subjects ate snacks and Table 4.2 shows the most frequent snack foods consumed. Sweets, chocolate and soft drinks formed the highest percentage of snack food consumption. These results are consistent with those of Musaiger and Gregory (1992) who reported that corn-puffs (popcorn), carbonated beverages, chocolates, uncarbonated canned drinks and fruits were the main foods consumed as afternoon snacks. The high consumption of sweets, chocolate and soft

beverages have a negative influence on adolescent health. Firstly, they will replace the nutritious foods such as fruits and vegetables; secondly, they have high energy density. An increase in the consumption of high-energy foods plus a low physical activity is the main contributors to obesity (Goran and Treuth, 2001).

Table 4.2: Percentage of snack foods consumed

Foods	Percentage
Sweets and chocolate	65
Soft drinks	60
Fruits	52
Potato chips	47
Ice cream	47
Fruit juice	38
Sandwiches	31
Tea	28
Mixed nuts	26
Popcorn	16
Coffee	6

4.4. Health status

The Gulf countries have experienced a rapid change in food habits and lifestyle as a result of oil discovery. Consequently non-communicable diseases, such as diabetes mellitus and cardiovascular diseases (CVD) have become more prevalent (Musaiger, 1987). The prevalence of diabetes mellitus among adults (15 years and over) ranged from 8%-14% (Musaiger, 1994). It has previously been reported that the overall diabetes prevalence in UAE is 11% in males and 7% in females aged 30-64 years. In another study, 19-25% of subjects had systolic blood pressure more than 140mm Hg (El Mugammer *et al.*1995).

CVD is now the leading cause of death in UAE since 1990, contributing 24% of the total annual registered death in 1998 (Ministry of Health, 2001). In this study, subjects reported the appearance of diabetes mellitus and hypertension in themselves

and their parents (Table 4.3). The results of this study are consistent with previous findings.

Table 4.3: Percentage of subjects and their parents diagnosed with diabetes and hypertension

Groups	Diabetes mellitus	Hypertension
Adolescents	1	2
Parents		
Fathers	18	12
Mothers	12	17

4.5. Lifestyle

As a result of oil discovery, UAE has undergone a rapid change in the socio-economic situation. The population has moved from a simple Bedouin tribe unsettled nomadic society to a commercial, modern business society. As a consequence, a decrease in mobility has been seen due to well-equipped homes, luxury cars and high dependence on housemaids in home management.

4.5.1. Television watching

Nowadays, television viewing and other devices like computers and video are among the favourite leisure activities in adolescents, which increase the prevalence of sedentary activities (French *et al.* 2001). In this study, 82% of the subjects spent two hours or more in front of a television screen. Table 4.4 shows the frequency of television watching among the subjects.

Table 4.4: Percentage of subjects watching television (daily)

Number of hours	Number	Percentage
0.5-<2.0	146	17
2.0-<4.0	403	46
≥4.0	329	36

Almost half of the subjects watched television for 2.0-<4.0 hours per day and only one percent of subjects did not watch television.

Television watching is the leisure time activity which has been most studied. Hussey *et al.* (2001) evaluated the amount of regular activity and time spent in sedentary occupations in children aged 7-9 years, and reported that 78% of the children were spending 1-3 hours daily sedentary in front of a screen. Hernandez *et al.* (1999) showed that schoolchildren in Mexico spent four hours daily in front of a television screen. Previous studies in the UAE or neighbouring countries have not reported television viewing hours.

The negative influences of spending a long time in front of the television screen are:

(1) increase in the sedentary behaviour in leisure time and its effect on the increase in the prevalence of obesity.

(2) the role of television viewing in the increase in food consumption as a result of food advertisements which may attract children and adolescents.

(3) encouraging the consumption of foods while subjects watch the television; these foods tend to be sweets, potato chips and soft drinks which are contributors of obesity (Robinson, 2001).

4.5.2. Physical exercise/activity

Undertaking physical exercise is a difficult problem in the UAE due to factors such as high temperatures during daylight hours and the exclusion of undertaking physical exercise outdoors. In addition, women are proscribed from wearing clothes more suitable for exercise. This may impede their interest in physical activity.

The percentage of subjects who undertook different types of exercise, on a weekly basis is shown in table 4.5.

Table 4.5: Percentage of subjects undertaking different types of exercise

Types of exercises	Number	Percentage
Walking	400	59
Running	121	18
Aerobics	238	35
Swimming	99	15

The negative influence of not undertaking weekly physical exercise could be a

main contributor of obesity in this community. In addition, the presence of other factors, such as extended television viewing and the consumption of different types of snacks will increase the prevalence of obesity among this population.

4.5.3. Housework

The greater availability of housemaids (Table 4.1) and the availability of electrical household devices have led to a decrease in housework. Table 4.6 shows the percentage of subjects carrying out different housework, on a weekly basis.

Table 4.6: Percentage of subjects undertaking housework

Types of housework	Number	Percentage
Dish washing	255	48
Dusting	195	37
Cooking	60	11
Ironing	275	52
Vacuuming	264	50

As mentioned in the earlier sections, the availability of housemaids may contribute to a decrease in physical activity of the subjects due to the high dependence on the housemaid in house management.

Overall the vast change in lifestyle as a result of oil discovery may affect many aspects of life such as food habits, food intake and physical exercise. These factors are all known contributors to obesity.

4.6. Summary

Contemporary lifestyle in the UAE is characterized by:

(1) the consumption of high energy dense snack foods.

(2) increased television viewing.

(3) little participation in physical activity.

(4) extensive use of motor cars.

(5) total reliance on housemaids.

All of the above conspire to contribute to the increased prevalence of obesity in the adolescents studied.

CHAPTER FIVE: ANTHROPOMETRIC MEASURES IN YOUNG CHIDREN AND ADOLESCENT FEMALES IN THE UAE

Anthropometric measurements are an important tool in the assessment and evaluation of growth. They are widely used for diagnostic and perspective purposes. In this chapter, anthropometry is used to describe the nutritional status of adolescent females aged 10-19 years in the United Arab Emirates (UAE).

5.1. Growth status of UAE female young children and adolescents

In order to assess the growth status of the UAE female adolescents, weight, height, mid-upper-arm circumference (MUAC), and triceps skinfold thickness (TSF) were measured. In addition, body mass index (BMI) and mid-upper arm muscle circumference (MUAMC) were calculated.

The mean and standard deviation (SD) of height weight and BMI for the sample is shown in Table 5.1.

Table 5.1: Height, weight and BMI in UAE adolescent females (mean and SD) compared with reference values

Age (yrs)	*N*	Height (cm)			Weight (kg)			BMI (kg/m^2)		
		Ref	Mean	SD	Ref	Mean	SD	Ref	Mean	SD
10	10	138.0	140.2	14.1	32.5	38.3	11.6	16.8	19.2	3.9
11	85	144.0	146.0	11.4	37.0	40.8**	10.8	17.5	19.2**	5.1
12	132	152.0	151.3	9.2	41.5	45.5**	13.0	18.1	19.7***	4.7
13	139	157.5	152.3***	9.4	46.0	45.6	10.0	18.7	19.6**	3.6
14	133	161.0	156.6***	6.4	49.5	52.0	12.9	19.4	21.1***	4.8
15	130	162.0	156.4***	7.3	52.0	52.6	12.1	19.9	21.4***	4.2
16	116	162.5	158.8***	7.1	54.0	55.5	11.8	20.4	22.0**	4.4
17	99	163.0	159.6***	7.1	55.5	54.9	12.7	20.9	21.5	4.6
18	38	163.5	157.9***	5.6	56.5	57.8	17.8	21.3	23.1	6.8
19	15	163.5	157.2	13.4	57.5	59.1	13.1	21.5	24.3	6.7

Ref: Reference value (CDC, 2000); values were significantly different from reference values: **p< 0.01 and ***p<0.001

The results show a significant difference between the reference values and those found in the present study related to height, weight and BMI. The subjects in the present study were found to be significantly shorter than the reference values at ages 13-18 years. However, the mean weight of the subjects was significantly higher at ages 11 and 12 years old and the mean BMI was significantly higher in our study at ages 11-16 years. These findings are similar to those of Musaiger (1998b) who reported that, in Kuwait, the children were shorter than American children and tend to be heavier during the adolescent period.

In Table 5.2, the results show that the subjects from the UAE have MUAC significantly lower than the reference values at ages 12-14 and 17 years and have MUAMC significantly lower than the reference values at ages 11-17 years. The TSF was found to be significantly higher in our subjects compared to the reference value at ages 10-15 and 17 years.

Table 5.2: MUAC, MUAMC and TSF in UAE adolescent females (mean and SD) compared with reference values

Age	N	MUAC (mm)			MUAMC (mm)			TSF (mm)		
(yrs)		Ref	Mean	SD	Ref	Mean	SD	Ref	Mean	SD
10	10	210	240.5	57.4	170	177.1	44.0	12	20**	6
11	85	224	224.7	46.7	181	162.6***	33.9	13	20***	7
12	132	237	219.9**	55.1	191	171.0***	31.5	14	19***	7
13	139	243	235.0*	42.7	198	179.5***	28.6	15	18***	7
14	133	252	243.0*	42.7	201	185.8***	31.0	16	18**	7
15	130	254	248.5	42.3	202	190.7**	33.7	17	18*	5
16	116	258	248.3	43.4	202	193.3*	32.5	18	18	5
17	99	264	242.8***	44.5	205	189.1***	31.4	19	17**	5
18	38	258	253.4	39.7	202	194.6	28.2	18	19	5
19	15	265	278.2	58.3	207	217.4	40.5	18	19	7

Ref: Reference value (NHANES I, 1981); values were significantly different from reference values: * $p<0.05$, ** $p< 0.01$, and *** $p<0.001$.

5.2. Height

The average height of the sample ranged from 140.2 cm at 10 years of age to 159.6 cm at 17 years of age (Table 5.1). Al-Haddad *et al.* (2000) conducted a study in one Emirate in the UAE and found that the average height for females aged 10 years was 131.2cm and 156.9cm for subjects aged 17 years. The difference between the two studies may be due to the nature of Al-Haddad sample selection (all subjects chosen were supposed to be native Emirati). In contrast, the present study included non-Emirati girls.

In this study, most of the subjects' height ranged between 25^{th}-75^{th} percentiles of the CDC standards (Table 5.3) except at age 10 years, where subjects were at values >90^{th} percentile. In a study from the same region, Musaiger *et al.* (1989) found that the median height for girls aged 11 years was between 5^{th} and 25^{th} percentiles of NCHS standards and between 10^{th} and 25^{th} for girls aged 12 years. In another study, Musaiger (1998b) showed that the median height of Omani girls was between 5^{th} and 25^{th} percentiles of the NCHS standards. Whilst these studies cannot be compared directly, they suggested that height in the UAE adolescent females is similar to those seen in other regions close to the UAE.

Table 5.3: Percentage of subjects in each height centile

Age	<5^{th}	5^{th}-<25^{th}	25^{th}-<75^{th}	75^{th}-<90^{th}	>90^{th}
10	10	10	20	20	40
11	6	8	46	20	20
12	8	18	45	21	8
13	20	25	44	8	3
14	8	42	44	5	1
15	23	31	35	9	2
16	21	21	47	9	2
17	16	24	49	9	2
18	21	26	48	5	0
19	20	20	60	0	0

In Jordan, the height for age for the Jordanian girls ranged from the 5^{th}-10^{th} percentiles until the age of 14.5 years and above 10^{th} until the age of 17.5 years (Hasan *et al.* 2001). The results of our study were inconsistent with previous studies except at

age 14 years, forty-two percent of the subjects were between 5th and 25th as reported in Musaiger (1998b). The inconsistency of the results may be due to the use of different reference values. The reference values of Hasan *et al.* (2001) were the same as in our study (CDC growth charts, 2000), while in Musaiger (1998b) NCHS standards were used.

5.3. Body Weight

Mean body weight ranged from 38.3 to 59.1 kg (Table 5.1). In this study, the weight ranged between 25th to 75th percentiles except at age 10, 11, 18 and 19 years. The distribution of the sample on the percentiles is shown in Table 5.4.

Musaiger et al (1998b) found, in a comprehensive study on growth pattern of adolescents girls aged 11-18 years in Bahrain, that the median weight ranged between 10th to 50th percentiles of NCHS standards and in another study in Oman, Musaiger (1998b) showed that the median weight of Omani girls was between 10th to 25th percentiles of NCHS standards.

Hasan *et al.* (2001) reported that the median body weight of Jordanian girls was below 50th percentile before age 12.5 years and above 50th at 17.5 years of age. In our study, the weight of one third of the subjects at age 19 years ranges between 75th - <90th percentiles. For this reason these studies cannot compare directly with our results. They suggested that body weight of adolescent females in the UAE children is similar to those seen in other regions close to the UAE.

Table 5.4: Percentage of subjects in each body weight centile

Age	<5th	5th-<25th	25th-<75th	75th-<90th	>90th
10	0	30	20	20	30
11	6	21	33	20	20
12	12	15	40	18	15
13	7	12	43	24	14
14	12	13	47	16	12
15	10	25	47	8	10
16	10	18	46	15	11
17	15	21	44	11	9
18	26	16	32	18	8
19	20	7	33	33	7

5.4. Body Mass Index (BMI)

BMI was used for the definition of overweight and obesity in adolescents. The cut-off point for overweight was between ≥85th and <95th percentile and ≥95th for obesity. This sample was analysed using this definition.

As shown in Table 5.5, the highest prevalence of obesity was seen at age 11 years (15 %), while the highest prevalence of overweight occurred at 10 years of age.

Table 5.5: Percentage of subjects in each BMI centile

Age	<3	3-<25	25-<75	75-<85	85-<95	≥95
10	0	20	30	10	30	10
11	8	19	34	8	15	15
12	10	17	37	10	12	14
13	8	18	43	15	10	6
14	8	16	39	10	18	9
15	6	18	39	20	11	6
16	7	19	38	14	13	9
17	10	23	44	7	7	9
18	16	16	38	8	14	8
19	22	7	29	14	21	7

In general, the prevalence of overweight in this sample ranged from 7% at age 17 years to 30% at age 10 years. The prevalence of obesity ranged between 6% at age 13 and 15 years to 15% at age 11 years.

Figure 5.1 shows the percentage of underweight, overweight and obese subjects.

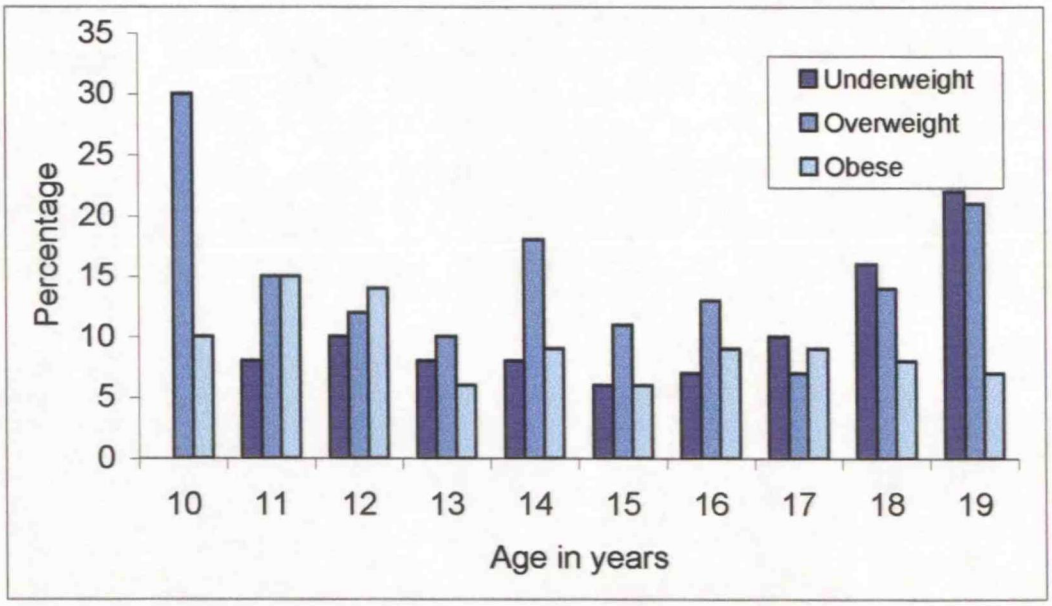

Figure 5.1: Percentage of underweight, overweight and obese subjects

In the UAE, Al-Haddad *et al.* (2000) found that the prevalence of overweight in school children aged 6-16 years was 9% among girls and 9% among boys, whereas the prevalence of obesity was 8% in both sexes. The highest percentage of obesity was at age 16 years (11%) and the highest percentage of overweight was at age 12 years (15%). The results of this study were inconsistent with the previous study. This difference may be due to the nature of his sample (all were supposed to be native Emirati) whereas our study included non-Emirate girls and the use of different reference values. More importantly, the present study included five Emirates in the UAE, while Al-Haddad's study was conducted on one single Emirate of the UAE only.

The results of this study are consistent with some previous studies, undertaken in the same area (Gulf countries). In Saudi Arabia, Abahussain *et al.* (1999) assessed

the nutritional status of Saudi adolescent girls aged 12-19 years and found that 11% of the girls were underweight, 61% were normal weight and 28% were overweight or obese. Also in Saudi Arabia, Al-Shammari *et al.* (2001) reported that the prevalence of overweight and obesity was 11% and 9% respectively in female and male subjects aged 6-17 years. Females had higher rates of overweight and obesity and the highest prevalence of overweight and obesity was among children aged 6-10 years.

In Kuwait, Al-Mousa and Parkash (2000) reported that the prevalence of obesity and overweight was 31% among females aged 14-17 years.

In Jordan, Hasan *et al.* (2001) reported that Jordanian girls were above the 50th percentile for BMI values until the age of 13.5 years and at 75th percentile at the age of 17.5 years.

Figure 5.2 shows the prevalence of combined overweight and obese subjects.

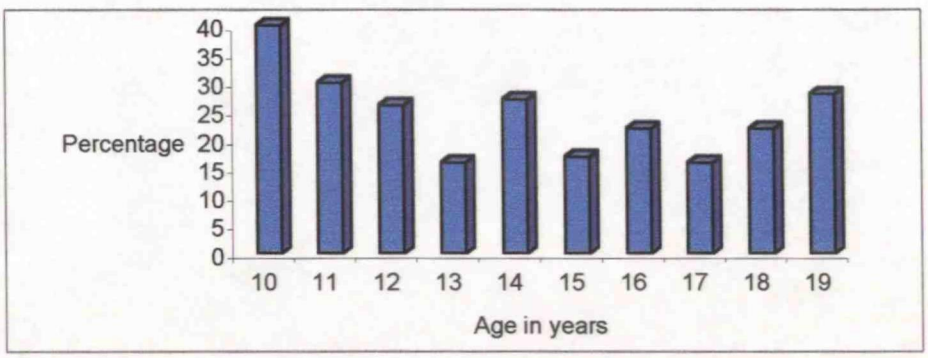

Figure 5.2: Percentage of combined overweight and obese subjects

The prevalence of overweight and obese subjects (i.e. ≥85th percentile) ranges from 16% at age 13 and 17 years to 40% at age 10 years. Many studies have considered overweight and obese subjects as one group (Abahussain *et al.* 1999; Al-Mousa and Parkash, 2000; Al-Haddad *et al.*2000). The results of this study are alarming. At the age 10-12 years growth spurt occurs in girls (Bogin, 1999) and the highest prevalence of overweight and obesity was observed at this age. In addition, age 19 years is the end of the adolescent stage and the beginning of the adulthood period, and in this study, the prevalence of overweight and obesity was high which may increase the prevalence of adulthood obesity.

5.5. Mid-upper arm circumference (MUAC)

The MUAC ranged from 220 mm to 278 mm and was significantly lower than the reference values of NHANES I (1971-1974) at ages 12-14 and 17 years (Table 5.2). Most of the subjects were between 25th to 75th percentiles of NHANES I (1971-1974) except at age 10 and 19 years, as shown in Table 5.6. At age 10 years, most of the subjects were at >90th percentile, and at age 19 years were between 75th and <90th percentiles.

Table 5.6: Percentage of subjects in each MUAC centile

Age	<5th	5th-<25th	25th-<75th	75th-<90th	>90th
10	10	20	10	20	40
11	22	17	31	17	13
12	28	22	31	5	14
13	23	19	41	9	8
14	25	25	31	11	8
15	13	27	37	14	9
16	20	26	41	2	11
17	28	32	26	10	4
18	25	11	46	11	7
19	9	27	9	37	18

The arm contains subcutaneous fat and muscle therefore a decrease in MUAC may reflect a decrease in muscle mass or fat tissue, or both (Gibson, 1990). In this study, it was found that girls at age 10 and 19 years were above the 75th percentile and that the percentage of overweight and obesity were the highest at these ages. The correlation between BMI and MUAC is shown in Figure 5.3.

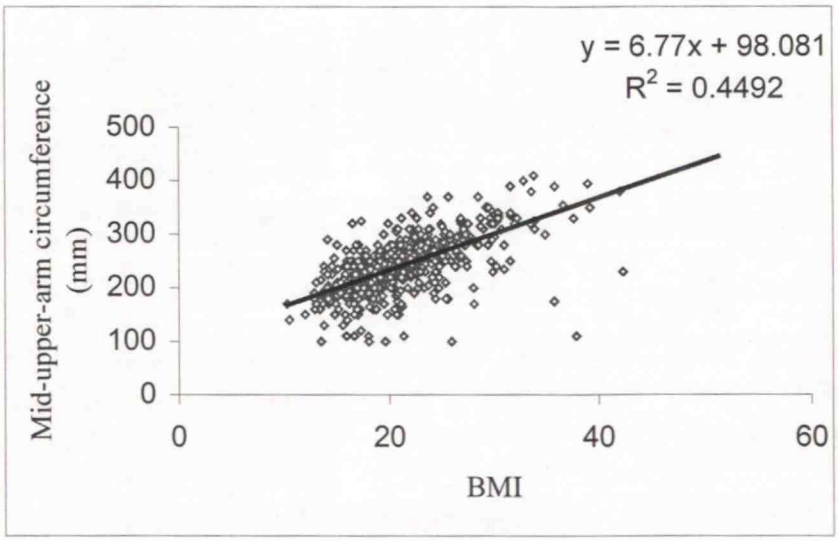

Figure 5.3: Correlation between BMI and MUAC in adolescent girls

There was a significant ($p<0.01$) positive correlation between BMI and MUAC for all age groups.

Previous studies in the UAE and neighbouring countries have not reported MUAC measurements.

5.6. Mid-upper arm muscle circumference (MUAMC)

The average MUAMC of the sample ranged from 163 to 217 mm and was significantly lower than the reference values of NHANES I (1971-1974) at ages 11-17 years, as shown in Table 5.2. One report on MUAMC (Musaiger and Gregory, 2000) of children aged 6-18 years in Bahrain showed that MUAMC ranged from 12.9-22.2 cm, which is consistent with the values in this study.

Table 5.7: Percentage of subjects in each MUAMC centiles

Age	$< 5^{th}$	5^{th}-$<25^{th}$	25^{th} - $<75^{th}$	75^{th} - $< 90^{th}$	$> 90^{th}$
10	30	10	0	10	50
11	0	7	36	31	26
12	35	28	23	7	7
13	41	16	30	6	7
14	34	22	30	8	6
15	37	12	30	11	10
16	22	20	38	10	10
17	28	39	19	10	4
18	29	21	25	21	4
19	9	18	9	27	37

Most of the subjects were between 25^{th} to 75^{th} percentiles of NHANES I (1971-1974) except at ages 10, 11 and 19 years (Table 5.7). More than 50% of the subjects in these age groups were between 75^{th} and $<90^{th}$ and $>90^{th}$ percentile.

The ages 10, 11 and 19 years showed a high prevalence of overwieght and obesity (Figure 5.2). There was a significant ($P<0.01$) positive correlation between BMI and MUAMC as shown in Figure 5.4. Conversly, subjects at age 14 years showed a high prevalence of overweight and obesity (Figure 5.2) but their MUAMC were as the rest of the sample.

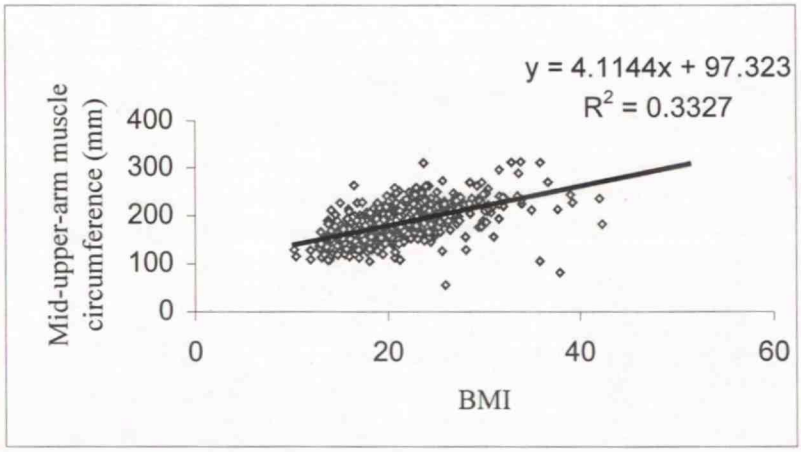

Figure 5.4: Correlation between BMI and MUAMC

5.7. Triceps skinfold thickness (TSF)

Must *et al.* (1991) used 85th and 95th TSF to define obesity and superobesity, respectively. In this study, TSF was measured only and also used to calculate MUAMC. The average TSF of the subjects ranged from 17 mm to 20 mm and the results were significantly higher than the reference values NHANES I (1971-1974) at ages 10-15 years and at 17 years (Table 5.2). In this study, most TSF ranged between 25th and <75th percentiles except for the first three age groups (10, 11, and 12 years), of which more than quarter were above 90th percentile (Table 5.8). These age groups also showed the highest percentage of overweight and obesity, as shown in Table 5.5.

Table 5.8: Percentage of subjects in each TSF centiles

Age	$< 5^{th}$	5^{th}-$<25^{th}$	25^{th} - $<75^{th}$	75^{th} - $< 90^{th}$	$> 90^{th}$
10	0	0	30	30	40
11	0	7	36	31	26
12	4	6	40	22	28
13	2	11	57	16	14
14	7	11	55	15	12
15	2	2	70	12	14
16	3	19	61	7	10
17	9	3	74	13	1
18	0	11	68	14	7
19	9	9	46	27	9

It is significant to note that the age group that showed the greatest prevalence of obesity (i.e 10 years), assessed using BMI, also showed the highest prevalence of obesity when assessed using TSF. This confirms that in this age group (10 years) obesity defined using BMI or TSF shows similar concordance.

The study has described the growth patterns of the UAE female adolescents. Mean values for weight, height, BMI, MUAC, MUAMC and TSF have been presented. In addition, the age groups at increased risk of health problems, mainly from 10-12 and 19 years, have been highlighted.

In girls, the growth spurt usually starts at age 10-12 years. Therefore, more awareness should be given to these groups to decrease the prevalence of overweight and obesity in the community.

5.8. Summary

A survey of children in the UAE using a variety of anthropometric measurements indicated that obesity is prevalent at a maximum at the following ages 10, 11, 12, 14 and 19 years. This observation needs further elaboration. It is proposed that this increase in obesity seen at these ages may be due to:

1. High dependence on housemaids which may decrease the physical

activity of the adolescents in the UAE.

2. High consumption of snack foods such as, sweets, chocolate, and soft beverages.
3. Increased number of hours of television viewing and its effect in the increase of sedentary activities.
4. Physical activity was only confined to once per week. This limited level of physical activity may also be a main contributer of obesity among adolescent females in the UAE.

CHAPTER SIX: ENERGY AND NUTRIENT INTAKE IN YOUNG CHILDREN AND ADOLESCENTS

The rapid change in socio-economic status in the UAE, has played an important role in altering the food consumption patterns of the population. Studies on food consumption in the UAE are limited and have been undertaken only in adults. The present study has focused on the food consumption patterns and energy and nutrient intakes in adolescent females.

The results presented here are from a sub-sample of 41 adolescents studied in detail.

6.1. Food frequency Questionnaire

The following results were obtained using food frequency questionnaire

6.1.1. Bread and cereals

The first items addressed are bread and cereals products. Ten items, seven types of bread and three starch foods, were included in this section. Two types of bread were known to be traditional breads in the UAE (*Rgag* and *Cho-bab*). Table 6.1 shows the frequency of response.

Table 6.1: Percentage of subjects consuming different bread

Food item	Daily	Weekly	Monthly	Never
Arabic white bread	75	25	0	0
Baguette	45	46	0	9
Cho-bab	5	11	11	73
Macaroni	5	59	25	11
Rgag	0	30	20	50
Rice	61	27	7	5
Whole wheat	0	9	11	80
Sliced bread	2	21	9	68
Burger bread	5	34	18	43
Corn flakes	18	23	14	45

There has been a severe change in food consumption patterns as a result of the oil boom; dates, rice and fish were known to be the traditional foods. Musaiger, (1998a) reported that the consumption of brown bread has been replaced by white bread. The majority of subjects consumed Arabic white bread, rice and baguette on a daily basis, while many did not consume whole wheat bread or their own traditional bread *cho-bab*.

One of the main reasons for the decrease in the consumption of the traditional bread may be due to the dependence on the housemaids in the preparation of foods. Housemaids are non-local and may not know how to prepare these types of bread. In addition, the availability of many types of bread in the markets, as a result of a high percentage of immigrants, may lead to greater choice of food.

In this study, the consumption of cornflakes was 18% on a daily basis and macaroni was around 60% on a weekly basis. This may be due to the effect of expatriates, high dependence on housemaids in food preparation and UAE being an open market for food from all over the world.

6.1.2. Vegetables and fruits

Two groups of vegetables were studied: dark green leafy vegetables and root vegetables. In addition, the frequency of consumption of 12 types of fruit, plus fruit juices, was assessed. Table 6.2 shows the frequency of the consumption of vegetables and fruits.

Studies on the consumption of vegetables and fruits in adolescents show a low consumption worldwide. Speck *et al.* (2001) assessed the eating habits in 446 students (sixth to eighth grade) and concluded that adolescents consume higher number of servings of fats, sweets, and meats compared to the number of vegetables and bread.

In a study to assess the adolescent food habits in Switzerland, Cavadini *et al.* (1999) concluded that a significant proportion of adolescents do not consume milk, fruit and vegetables on a daily basis.

Table 6.2: Percentage of subjects consuming different vegetables and fruits

Food item	Daily	Weekly	Monthly	Never
Dark green leafy vegetables	23	41	14	23
Root vegetables	16	52	18	14
Other vegetables	7	32	25	36
Potato chips	52	27	18	2
Apples	39	59	2	0
Banana	23	61	9	7
Mango	18	48	27	7
Oranges	46	39	7	9
Peach	7	23	18	52
Pear	11	32	34	23
Dates	30	36	18	16
Apricots	0	30	25	45
Kiwi	5	34	30	32
Grapes	9	48	30	14
Strawberries	2	30	30	37
Watermelon	18	48	23	11
Fresh fruit juice	27	30	7	36

The results of this study are consistent with the previous studies. The percentage of adolescents who consume dark green leafy vegetables, root vegetables and other types of vegetables on a daily basis were 23%, 16% and 7% respectively, indicating that the majority of the subjects do not consume vegetables on a regular basis. In addition, this study showed a higher consumption of potato chips (52%) on a daily basis. This may be due to many factors, for example potato chips are a common food sold at school to the students during breaks between lessons and they are also consumed as a snack while adolescents watch the television.

This study showed that the consumption of fruits on a daily basis is higher than that of vegetables. Oranges, apples, dates and fresh fruit juices are the highest

among the fruits. Dates are among the highest fruits consumed on a daily basis although consumption is lower than in past years. Dates are known to be the main fruit in this country in different forms (fresh and dried). However, the new generations do not consume dates as a main fruit, which may due to the effect of the open market and the availability of different types of fruit.

Musaiger and Radwan (1995) reported that 59% and 41% of females aged 18-30 years in the UAE consume vegetables and fruits respectively on a daily basis. The consumption of vegetables and fruits is lower in adolescents compared with adults in the UAE.

6.1.3. Meat and meat alternatives

The meat and meat alternative group consisted of nine food items; legumes were included in this group. Table 6.3 shows the frequency of consumption.

Table 6.3: Percentage of subjects consuming meat and meat alternatives

Food item	Daily	Weekly	Monthly	Never
Lamb	14	27	11	48
Veal	2	48	9	41
Chicken	27	59	9	5
Fish	11	52	20	16
Organ meat	2	25	25	48
Shellfish	0	7	27	66
Sausages	0	30	23	48
Eggs	9	64	7	20
Legumes	16	57	16	11

The results show that chicken is the highest among the meat types consumed. The consumption of fish on a daily basis is low despite being considered one of the most important traditional foods in the UAE, but still it is consumed on a weekly basis.

As a result of the oil discovery, the UAE experienced a rapid change in dietary habits and the lifestyle; the availability of fast food restaurants changed dietary habits, especially in the younger generations. This can be seen in the increased consumption

of fried chicken and burgers, which has replaced fish consumption. The consumption of legumes has increased in the UAE as a result of immigrants who have influenced food consumption patterns. *Falafel* and *foul moudams,* two dishes eaten in the UAE and made of legumes, were introduced by an Arab group; in addition, Indian dishes like *keema* (broad beans) and *dhal* (lentils) have been introduced.

6.1.4. Milk and milk products

In this study, it is observed that subjects consume different types of milk and milk products on a daily and weekly basis. Lactose intolerance in children/adolescents has not been studied in the UAE.

Table 6.4 shows the frequency of the consumption of the milk and milk products group.

Table 6.4: Percentage of subjects consuming milk and milk products

Food item	**Daily**	**Weekly**	**Monthly**	**Never**
Whole fat liquid	30	25	7	39
Yoghurt	32	39	7	23
Butter milk	20	39	7	34
Powdered milk	14	32	5	50
Labneh	18	32	20	30
Cheese	57	39	2	2
Ice cream	23	48	23	7

In the past, camel milk was considered a main food item in the daily diet. However, the immigrant influence on food habits, for example processed cheeses and other milk products like *labneh* (hard yoghurt), has replaced the other milk group items.

Cheese is the highest among the milk and milk products consumed. The high consumption may be due to the UAE being an open market for food from all over the world and the effect of expatriates, for example cheese sandwiches are common foods sold at school to the students during breaks between lessons.

6.1.5. Fats and oil

Four food items were presented in the fats and oil group. Table 6.5 shows the frequency of consumption of these foods.

Table 6.5: Percentage of subjects consuming foods in the fat and oil group

Food item	Daily	Weekly	Monthly	Never
Butter	7	23	7	64
Oil	14	27	7	52
Olives	25	32	23	20
Mixed nuts	9	52	20	18

Musaiger (1998a) reported that the amount of fat and oils consumed per head in the Gulf Cooperation Council countries was on average 80 gram, which contributes 30% of daily energy supply. The annual per capita of oil and fat were increased from 2.4 kg in 1975 to 10.3 kg in 1980 (Musaiger, 1987). In this study, olives were the highest food consumed on a daily basis. Olives are not native to the Gulf area; pickled olives are an imported food consumed in the UAE due to the influence of the immigrants. While mixed nuts are the highest food item consumed on a weekly basis, they are generally consumed as a snack while the adolescent girls are watching television (see section 4.3.2).

6.1.6. Beverages

The consumption of soft drinks in adolescents is a concern. Data from surveys carried out in the USA from 1977-1979 and 1994 show a large increase in the consumption of soft beverages among children and adolescents (Harnack *et al.* 1999).

The hot climate in the Gulf countries (>50°C) motivates people to drink cold drinks, mainly in the form of carbonated beverages (Musaiger, 1987). Musaiger (1987) reported that the average consumption of soft drinks per capita in Bahrain is half a litre per day. In Kuwait, 68% of the population consume at least one carbonated beverage daily (Musaiger, 1987). In our study six types of drink were studied. Table 6.6 shows the frequency of consumption.

Table 6.6: Percentage of subjects consuming different beverages

Food item	Daily	Weekly	Monthly	Never
Arabic coffee	5	5	7	84
Instant coffee	7	34	11	48
Tea	39	30	0	32
Chocolate drink	18	34	20	27
Carbonated beverages	50	30	5	16
Artificial fruit juice	18	27	9	45

Carbonated beverages were consumed on a daily basis by half of the subjects. Tea is also a common beverage in this country, 39% of the subjects consumed tea on a daily basis. Tea is considered an important beverage in the UAE, especially at breakfast and between meals. It is considered as a part of *Fou-alla* (section 1.5.2.4). In this study, it was observed that coffee was the lowest type of beverage consumed; it is not customary for children and adolescents to consume coffee in the early ages in the Arab countries.

6.1.7. Sweets and desserts

Table 6.7 shows the frequency of consumption of sweets and desserts.

Table 6.7: Percentage of subjects consuming sweets and desserts

Food item	Daily	Weekly	Monthly	Never
Sugar	43	16	7	34
Jam	16	23	9	52
Honey	30	23	16	32
Chocolate	40	48	7	5
Biscuits	32	41	11	16
Cakes	23	39	25	14

The results show that sugar is among the highest food to be consumed on a daily basis; this may be due to the high consumption of tea, as the population prefer to

drink sweetened tea. The high consumption of chocolate, biscuits and cakes is also observed on a daily basis; as previously mentioned, they are often consumed as snacks (Table 4.2).

6.2. Summary

The overall changes in the socio-economic status in the UAE have affected the food consumption patterns in adolescent females in the UAE. Musaiger and Abuirmeileh (1998) reported that young people (20-49 years) were significantly higher in the consumption of chicken, eggs and cheese than older people (50 years and above) while older people were more likely to eat fish, rice and *Laban* (buttermilk). Similar results were found in this study. The consumption of the traditional foods, such as *rgag* and *cho-bab* (traditional bread), fish and dates, were not consumed on a daily basis. This could be due to many factors such as: (1) the effect of peers and friends at schools who may be from different countries and have different food habits; (2) the role of the housemaid in food preparation and the introduction of their own foods in the daily menus; and (3) the effect of food imported from different countries, exposing the adolescents to a much wider variety of foods.

6.3. Estimated food records

6.3.1. Meal Patterns

During the adolescence period, food habits in young people are easily influenced by their friends and advertisements, especially television (Samuelson, 2000). In general, adolescents of the UAE consume three main meals (breakfast, lunch and dinner) and one to three snacks per day. Table 6.8 shows the percentage of subjects consuming different meals and snacks.

Table 6.8: Percentage of subjects consuming main meals and snacks

Meal	Schooldays	Weekend	Average
Main meals			
Breakfast	96	95	96
Lunch	98	97	98
Dinner	84	93	89
Snacks			
Morning	73	83	78
Afternoon	86	85	86
Evening	44	46	45

Lunch is the main meal in most of the Arab countries and is usually consumed at home with the rest of the family. In this study, lunch was consumed by 98% of the subjects.

Ninety-three percent of the subjects consumed dinner at the weekend compared with just over 80% during the schooldays. This may be due to irregular meal timing during the weekend, for example subjects may wake late in the morning, so the distribution of meals throughout the day would be disturbed. In comparison their schooldays would start on average at 6.30 a.m, so they will have regular meal times.

The consumption of snacks was divided into three sections (1) morning snack, between breakfast and lunch and usually consumed at school; (2) afternoon snack, between lunch and dinner and usually consumed at home; and (3) evening snack, usually consumed after dinner. Snacks were consumed most frequently in the afternoon. This may be due to the convenient time, for example food may be

consumed while the subject is doing their homework or watching television. Also most people tend to sleep after lunch, so they would have something to eat upon waking. The evening snack was the least consumed. This may be due to the late dinner, which is often consumed around 9.00 p.m.

6.3.2. Estimated energy intake

The term "dietary reference values" (DRV) covers estimated average requirement (EAR), reference nutrient intake (RNI), lower reference nutrient intake (LRNI) and safe intake. The values apply to healthy people. The EAR is an estimate of the average requirement for energy. RNI is the amount of nutrient required to ensure that the needs of nearly all the group (97.5%) are being met; LRNI is the amount of a nutrient required for only the small number of people that have low requirements (2.5%); and the safe intake is the amount judged to be sufficient for everyone. There is no evidence that intakes above this level have any benefits and in some instances they could have toxic effects (Dietary Reference Values, 1991). Table 6.9 shows the DVRs for energy for females.

Energy needs are defined as the dietary intake necessary to balance the energy employed for internal work, external work, growth and repair of tissues (Giovannini *et al.* 2000).

Table 6.9: Dietary reference values for energy for females

Age	UK and WHO EAR[1]		USA AEA[2]	
	(MJ/day)	(kcal/day)	(MJ/day)	(kcal/day)
7-10	7.28	1740	8.3	2000
11-14	7.92	1845	9.2	2200
15-18	8.83	2110	9.2	2200
19-50	8.10	1940	9.2	2200

Source: Garrow *et al.* (2000). [1]EAR, estimated average requirement, [2]AEA, average energy allowances.

6.3.2.1. Energy intake in young children and adolescent females living in the UAE

The average energy intake of all subjects on schooldays was 4707 kJ (range 1948- 9528 kJ). At the weekend, the average energy intake was 6324 kJ (range 2552-11613 kJ). The wide range of energy intake may due to under-reporting of food intake, and/or dietary restraint. Figure 6.1 shows the mean (*SD)* energy intake during schooldays, weekend and the average for all subjects. The average energy intakes for both age groups are shown in Figure 6.2.

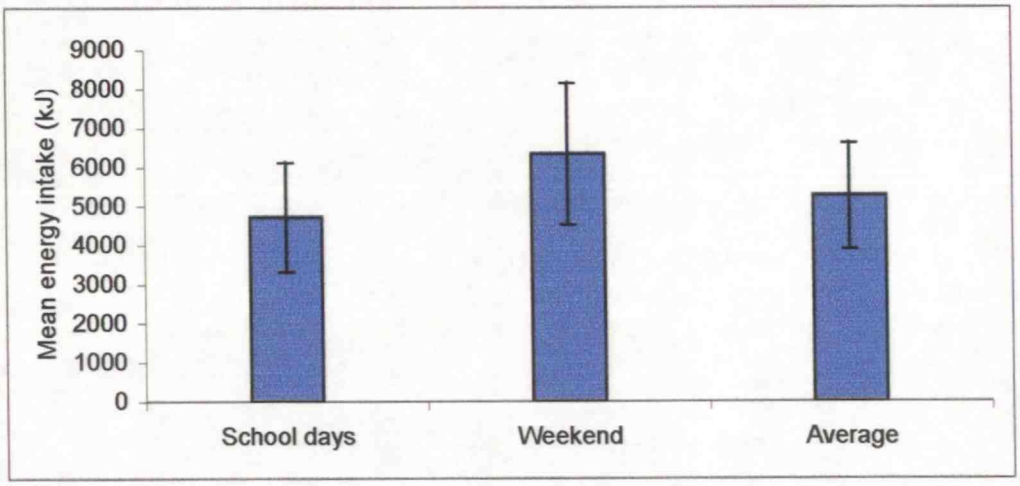

Figure 6.1: Mean ± *SD* energy intake of all subjects

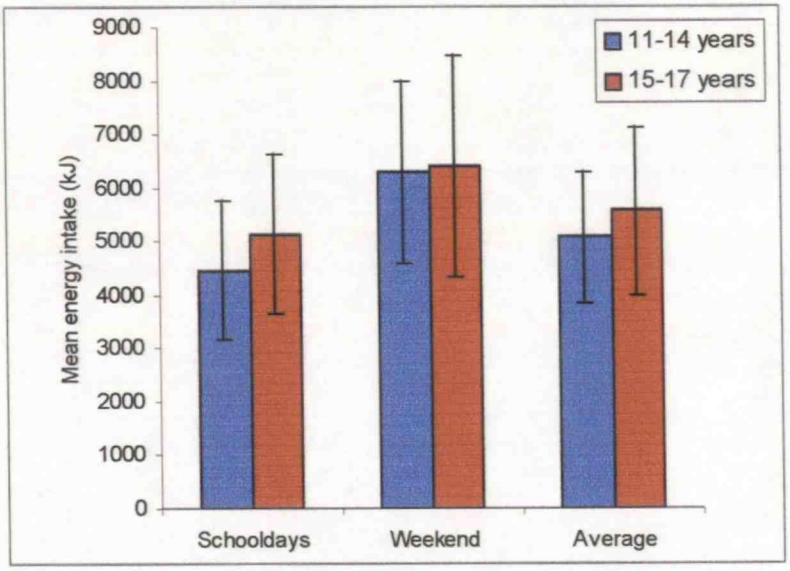

Figure 6.2: Mean ± *SD* energy intake in both age groups

The mean energy intake for both age groups was lower than the dietary reference values (Table 6.9). This may be due to underestimation, which is seen as one

of the main disadvantages of estimated food records (Bingham, 1987). In addition, all subjects surveyed were females and they tend to be more under-reporters than males and may be more prone to dietary restraint (Briefel *et al.* 1997).

A number of studies have been conducted to estimate the energy and nutrient intake of adolescents (Appendix 6.1). Post *et al.* (1987) assessed the differences in intake between schooldays and weekend days in 131 Dutch adolescents aged 12-17 years. They showed a higher energy intake during weekend compared to schooldays in both groups. The average energy intake for boys was exceeding 12.5 MJ at weekend while it was below 12.5 MJ on schooldays. Girls exceeded 10 MJ at the weekend while they were below 9 MJ on schooldays. The results agree with our findings, subjects tended to have a higher energy intake during the weekend. There was a significant difference in energy intake between schooldays and the weekend in both groups 11-14 years ($p<0.001$) and 15-17 years ($p<0.01$).

Energy intake at the weekend was similar in both groups, despite the different energy requirements. These results may partly explain the higher prevalence of overweight and obesity in the age group 11-14 years (Table 5.5).

The contributions made by breakfast, lunch, dinner and snacks to total energy intake was studied. The distribution of energy intake during schooldays and the weekend are presented in Figure 6.3.

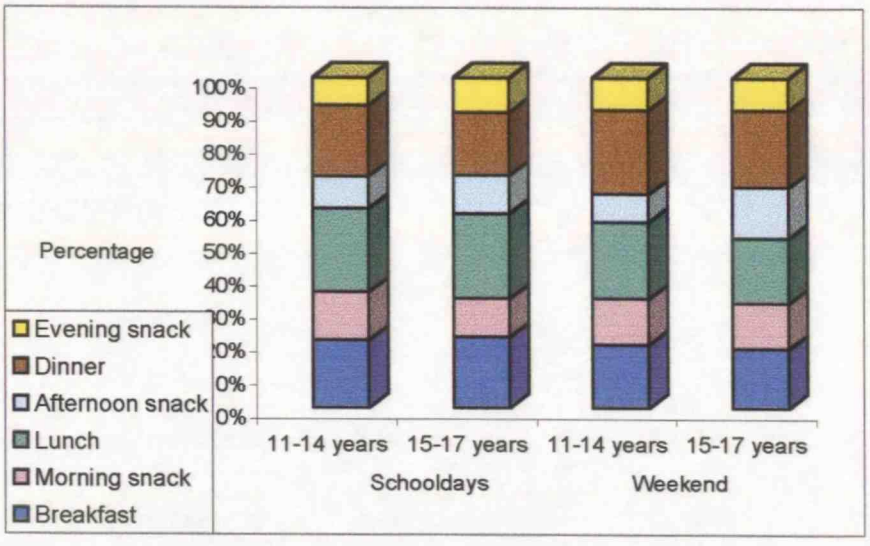

Figure 6.3: Distribution of energy (%) from different meals and snacks on schooldays and weekend.

In this study, there was no significant difference in the distribution of energy intake of meals during schooldays and weekend in the 11-14 years group. In the 15-17 years group there was a significant difference ($p< 0.01$) between the schooldays and weekend lunch meal. This may be due to disturbances of meal timing during the weekend; most of the subjects tend to wake up late morning, which may affect the distribution of energy through out the day. There was a significant difference ($p< 0.01$) in the percentage of energy from afternoon snack at the weekend between the two groups. This may be due to the lower energy intake at lunch in the 15-17 year group, thus the subjects may have increased their afternoon snack consumption.

Decarli *et al.* (2000) reported that main meals contributed 79% of energy and the rest were snacks in subjects aged 11-16 years. Samuelson et al (1996) reported that the main meals contributed 60-63% of the total energy intake and 37-42% as snacks during weekdays and weekends. In a study in Nigeria, Cole *et al.* (1997) reported that main meals were the only contributors of total energy. However, comparison between the results of this study and the previous studies (Table 6.10) is difficult, due to differences in food habits and culture.

Table 6.10: Previous studies on contribution of meals to energy intake

Author/year	Country	Age	Sex	*N*	Percent of energy			
					Breakfast	Lunch	Dinner	Snacks
Decarli *et al.* (2000)	Switzerland	11-16	M and F	NA	19	31	29	21
Samuelson *et al.* (1996)	Sweden	15	M and F	411				
Weekdays					18	18	24	37
Weekend					22	11	30	42
Cole *et al.* (1997)	Nigeria	11-17	F	22	22	41	37	-

Number (*N*), Females (F), males (M), not available (NA)

6.3.3. Macronutrient intake

The dietary reference values (DRV) for macronutrients are as follows: carbohydrate 50% of energy intake, protein 15% of energy intake and fat 35% of energy intake. In this study, the intakes of carbohydrate and protein were within these recommendations (Table 6.11).

Table 6.11: Percentage of total energy from protein, fat and carbohydrates

Macronutrient		Age group	
		11-14 years	15-18 years
Protein	(schooldays)	15	15
	(weekend)	14	14
	(average)	15	15
Fat	(schooldays)	32	31
	(weekend)	33	31
	(average)	33	31
Carbohydrate	(schooldays)	53	54
	(weekend)	53	55
	(average)	53	54

The results from this study show no significant difference between the percentage of total energy from carbohydrate, protein and fat consumed on schooldays and weekend in both groups and between groups.

Previous studies have failed to make quantitative measurements of daily energy and macronutrient intakes in Emirati adolescents. Previous worldwide studies investigating energy and macronutrient intakes are shown in Appendix 6.1. These studies reported a high consumption of fat, ranging from 28-44% of the total energy. Carbohydrate consumption ranged from 42-59% of total energy, while protein consumption was within the normal ranges.

The results of this study are consistent with the results of Anderson *et al.* (1995). Fat contributed to 31% of the total energy intake in the group aged 15-17 years. The inconsistency between our results and the previous studies (Appendix 6.1) is due mainly to the difference in the methods used in the assessment of energy and

nutrient intakes.

6.4. Physical activity levels in young children and adolescent females in the UAE

6.4.1. 24-hour activities

The participation in physical exercise is affected by the development of technology. Many children and adolescents prefer the indoor to outdoor activities, such as watching television, using the computer, and video games (Hill and Peters, 1998).

Figures 6.4 and 6.5 show the distribution of the activities over 24 hours for weekdays and weekends.

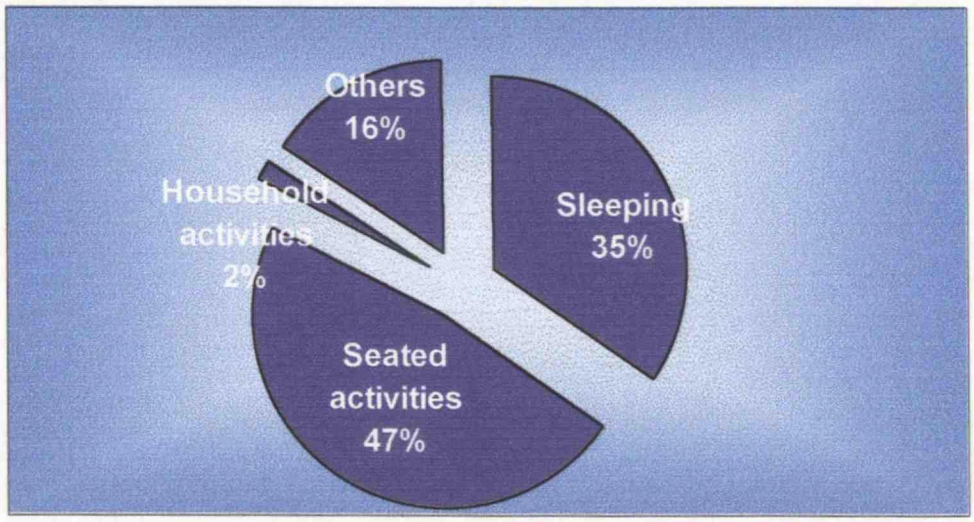

Figure 6.4: Distribution of different activities over 24 hours (schooldays)

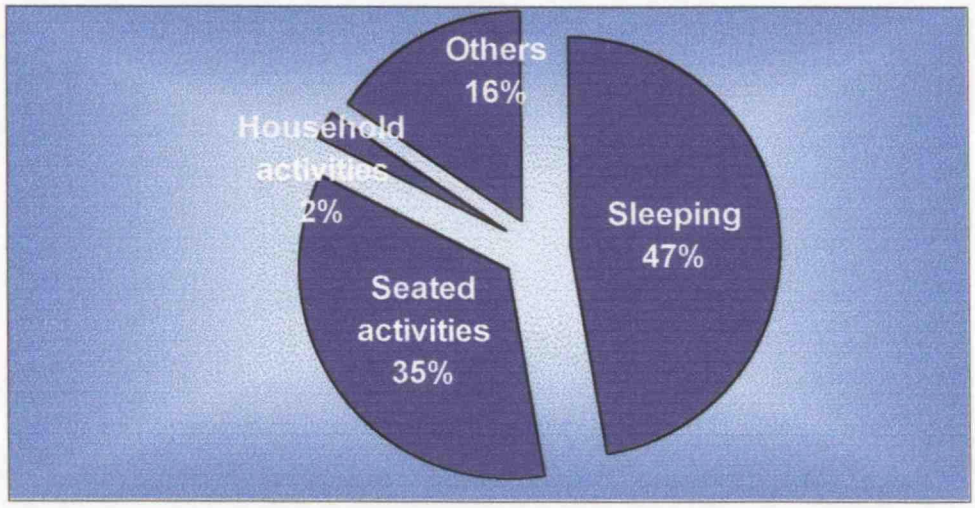

Figure 6.5: Distribution of different activities over 24 hours (weekend)

A significant feature in both figures (6.4 and 6.5) is the alarmingly large contribution made by the sedentary activity "sleeping".

There were significant differences in some activities between schooldays and the weekend (Table 6.12).

Table 6.12: Sleeping and seated activities (hours/24 hours)

Age group	Sleeping				Seated activities			
	Schooldays		Weekend		Schooldays		Weekend	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
11-14 years	8.4***	0.78	11.3	0.66	11.4***	0.98	8.3	0.93
15-17 years	8.4***	0.91	11.6	0.51	11.5***	0.8	8.6	1.0

Significant difference between schooldays and weekend*** P<0.001.

Table 6.13: Other activities and household activities (hours/24 hours)

Age group	Others				Household activities			
	Schooldays		Weekend		Schooldays		Weekend	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
11-14 years	3.7	0.84	3.9	0.71	0.39***	0.32	0.61	.051
15-17 years	3.7	0.96	3.4	1.27	0.40	0.49	0.40	0.47

Significant difference between schooldays and weekend*** P<0.001.

This study is the first to be undertaken in the UAE or other Gulf countries looking at physical activity over 24 hours. Many factors play an important role in physical activity and include:

(1) Cultural restrictions - females are not allowed to participate in any kind of physical exercise outdoors due to the conservative community.

(2) Wealthy community - as a result of oil discovery, the UAE has undergone a rapid change in the socio-economic situation. The population has moved from a simple Bedouin tribe unsettled society to a commercial, modern business society. In addition, most families depend on housemaids. This situation has made the household activities the lowest among the types of activities performed daily; furthermore the availability of electrical household devices has made household

work much easier.

(3) Weather - UAE is an arid and tropical country. The temperature exceeds 50°C between April and September; consequently the time between 1.00-4:30 p.m is a unhelpful time outdoors, therefore afternoon napping is practised. Sleeping was the predominant "activity" during both the weekend and schooldays.

Television watching is the predominant leisure time activity. This has been previously studied with respect to its relationship with overweight and obesity in children and adolescents. Robinson (2001) reported that television viewing causes obesity by one or more of three mechanisms: (1) displacement of physical activity; (2) increased calorie consumption while watching or caused by the effect of advertising and (3) reduced resting metabolism. Hernandez *et al.* (1999) investigated the association between physical activity, television viewing and other forms of video viewing with the prevalence of obesity among schoolchildren in Mexico. They found that, on average, children watched television for 4 hours per day. Hussey *et al.* (2001), evaluated the amount of regular activity and time spent in sedentary occupations in children aged 7-9 years and reported that 78% of the children were spending 1-3 hours a day sedentary in front of a television or computer screen.

In this study, television watching was the dominant leisure time activity among this group in the UAE. Table 6.14 shows the mean time spent watching television during schooldays and the weekend. There was a significant difference ($P< 0.05$) in the television watching time during the schooldays between the two groups. This may due to less time being needed to do their homework.

Table 6.14: Television watching during schooldays and weekends (hours/day) in both groups (Mean±SD)

Age group	Schooldays		Weekend	
	Mean	SD	Mean	SD
11-14 years	2.0	0.80	3.1***	0.83
15-17 years	1.6	0.67	3.2***	1.01

*** P<0.001 compared with the same group.

The results of this study are consistent with Hussey *et al.* (2001) and Hernandez *et al.* (1999). In the USA, 26% of children watch 4 or more hours of television per day and 67% watch at least 2 hours per day (Andersen *et al.* 1998).

The results of this study and the previous studies suggest that children prefer indoor activities. In this study, television watching during the weekend was significantly higher compared to schooldays, which may be due to the long period of time spend at home during weekends.

6.4.2. Estimation of physical activity levels (PAL)

Mean physical activity levels are shown in table 6.15.

Table 6.15: Mean physical activity levels (PAL)

Age group	Schooldays			Weekend		
	Mean	SD	Range	Mean	SD	Range
11-14 years	1.27	0.03	1.21-1.34	1.28	0.03	1.19-1.32
15-17 Years	1.27	0.04	1.20-1.31	1.26	0.02	1.20-1.29

There was no significant difference in mean PAL between schooldays and weekend in both groups or between groups (Table 6.15). There was no wide range in PAL during schooldays (Figure 6.6) and weekend (Figure 6.7).

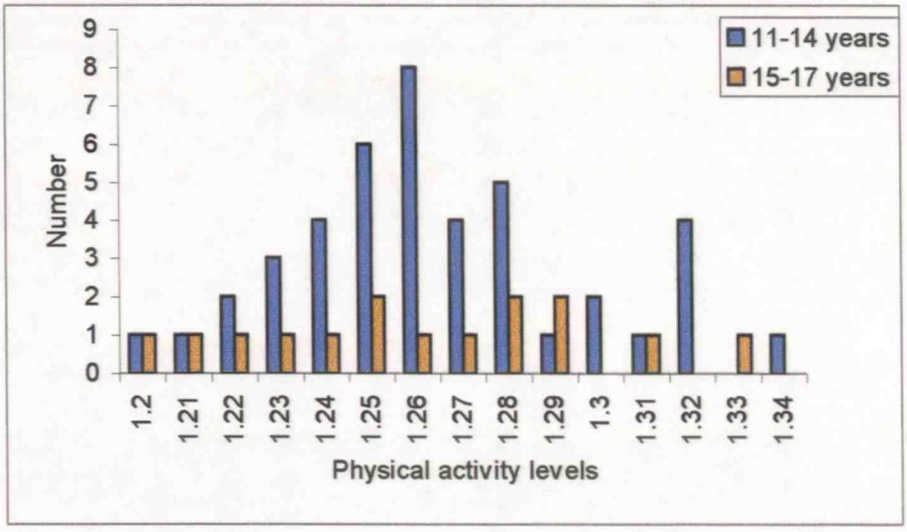

Figure 6.6: Distribution of PAL data in the females during the schooldays

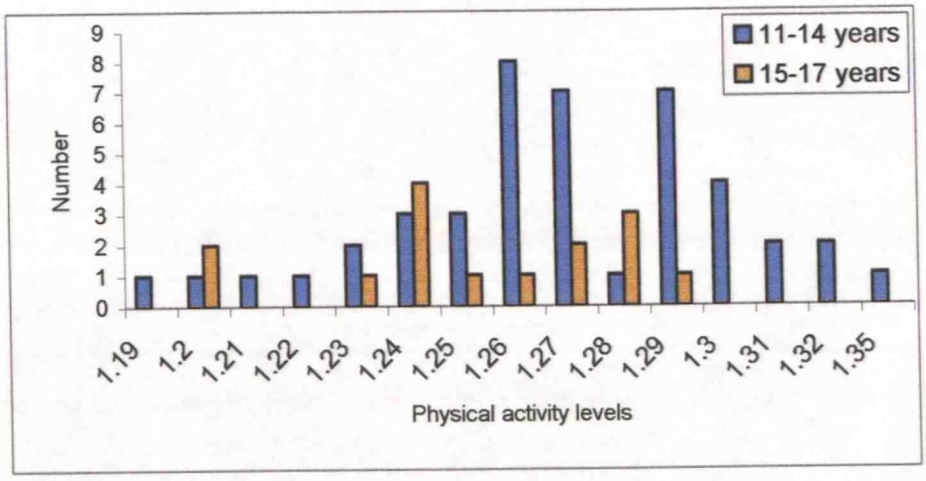

Figure 6.7: Distribution of PAL data in adolescents during the weekend

The average PAL value in this study was lower than the light PAL recommended by Torun *et al.* (1996). Few studies have measured PAL in children and adolescents. Henry *et al.* (1999b) evaluated PAL in children aged between 10-13 years and found that the mean PAL for all children was 1.52 (range 1.34-1.71), classified as light to moderate activity. Armstrong *et al.* (1990) found that British children have low physical activity based on heart rate monitoring.

In Sweden, PAL was measured in adolescent girls aged 15 years using activity diaries (Bratteby *et al.*1997b) and it was found that PAL was 1.95 for boys and 1.80 for girls. The results of the Bratteby study were validated by the DLW method and it was concluded that the activity diary provides a close estimate of PAL in population groups.

The results from our study show that the PAL values were lower than the previous studies. This may be due to the different cultures and the availability of outdoors activity.

The correlation between BMI and PAL in schooldays in both ages is shown in Figure 6.8. There was no significant difference in both groups.

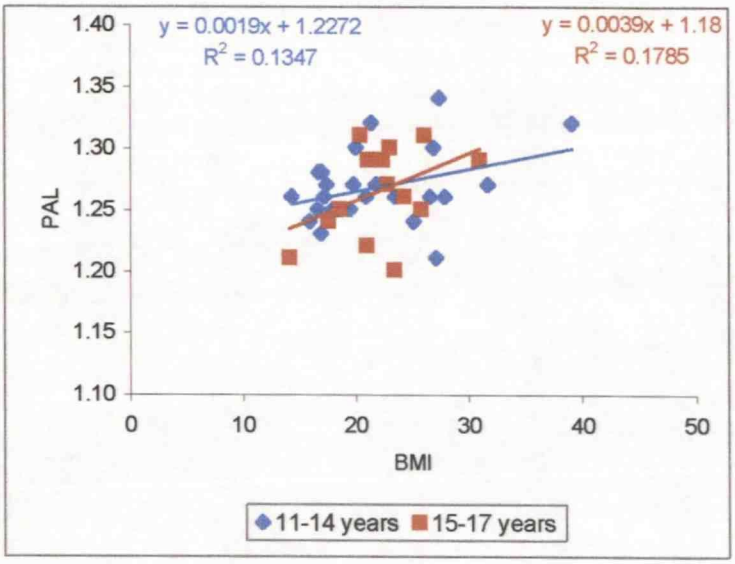

Figure 6.8: Correlation between BMI and PAL in both groups (schooldays)

A weak correlation between BMI and PAL was observed in age group 11-14 years and moderate in age 15-17 years in schooldays. The correlation between BMI and PAL in weekends in both age groups is shown in Figure 6.9 and there was no significant difference in both groups.

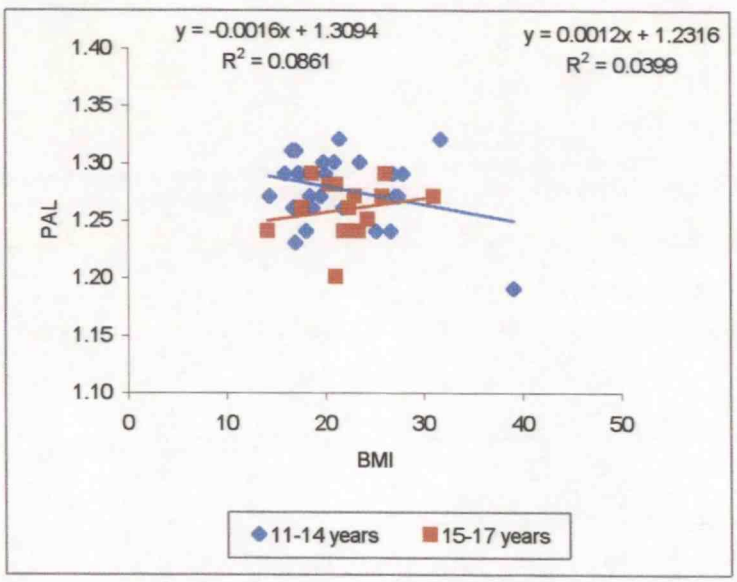

Figure 6.9: Correlation between BMI and PAL in both groups (weekends)

The Age group 11-14 years showed a weak negative correlation between BMI

and PAL.

The association between BMI and PAL is hard to explain, as it is impossible to ascertain which is the cause and effect. Do people become obese because they have low PAL or do they have a low PAL because they are obese? Such a question can only be answered using large longitudinal study.

6.5. Estimation of energy Expenditure (EE)

A factorial calculation was used to estimate daily energy expenditure. Table 6.16 shows the mean calculated BMR and the EE (PAL X BMR).

Table: 6.16: Predicted BMR* and EE (MJ)

Age group (years)	BMR		EE = (PAL X BMR)	
	Mean	*SD*	Mean	*SD*
11-14	5.85	0.85	7.44	1.09
15-17	6.14	0.58	7.76	0.82

* Using FAO/WHO/UNU equations

6.6. Estimation of energy balance

Energy balance occurs when energy intake (EI) equals energy expenditure (EE). Failure to achieve this balance will lead to energy imbalance. This energy imbalance can be positive or negative. In this study, the mean energy balance was negative (Table 6.17).

Table 6.17: Mean EI, EE and energy balance (MJ)

Age group (years)	EI		EE		Energy balance	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
11-14	5.07	1.23	7.44	1.09	-2.37	1.62
15-17	5.56	1.55	7.76	0.82	-2.20	1.41

Obesity can only be achieved if one is in positive energy balance. These findings are in contrast to the high prevalence of obesity. This may be due to a number of reasons: (1) under-reporting of energy intake and (2) low physical activity. Persistent under-reporting of energy intake will result in negative energy balance.

Many studies highlight this problem (Black and Cole, 2001). Bratteby *et al.* (1998) and Livingstone *et al.* (1992) reported that using a 7-day food record underestimates the energy intake by 20% in adolescents, especially those who have a tendency to gain weight (Livingstone *et al.* 1992). Possible reasons for underestimation include:

(1) Obesity - obese persons tend to under-report food intake (Johnson *et al.* 1998;

Heitmann, 1993).

(2) Gender - underestimation of food intake has been noticed more in females than in males (Briefel, 1997).

(3) Socio-economic status - low educational level, low social class and low income are linked to underestimation of food intake (Price *et al.* 1997).

(4) Lack of motivation in the subjects, especially with long periods of recording (Martin *et al.* 1996).

(5) Memory disturbances, especially with elderly people (Pannemans and Westererp 1993).

To overcome this problem, cut-off points were proposed by Goldberg *et al.* (1991) to identify low-energy reporters, where energy intake is expressed as a multiple of BMR (EI: BMR) and compared with presumed energy expenditure. The cut-off point that was used in this study was 1.06. Table 6.18 shows that 32 subjects were below 1.06, which means that 78% of the sample was under-reporting. Among the 41 subjects who took part in this study, 12 were overweight or obese and of these 11 were under-reporters. In the first age group (11-14 years), 11 out of 26 normal weight subjects were identified as under reporters (55%) which may be due to a decrease in accuracy in reporting as they were young children, while in age group 15-17 years, 11 out of 15 normal weight subjects were under reporters (85%) which may due to an increased concern with body weight in this age.

Table 6.18: Under-reporter subjects according to Goldberg cut-off point

Age group (years)	Total Number		Under-reporters			
			Normal weight		Overweight or obese	
	N	%	*N*	%	*N*	%
11-14	26	63	11	55	*9*	45
15-17	15	37	11	85	*2*	15

Reasons for possible underestimated food intake in this study include:

(1) lack of interest in this type of study in this area - this is the first study to have been carried out in this country not only in this age group but in the population as a whole.

(2) the subjects may have felt it a burden to record all food or drink they consumed for three days.

(3) this was the first such study in this country, therefore the nature of study may not have been very clear to them, although sessions were held to show the correct way of recording using household measures.

(4) subjects were females who are more likely to under-report than males (Briefel, 1997).

6.7. Summary

The vast increase in wealth as a result of oil discovery has had a major effect on the food habits of the UAE adults as well as children and adolescents. Many food items have been introduced to the population as a result of the UAE being an open market for food from all over the world. In addition, the high dependence on the housemaids in food preparation and the effect of immigrants have influenced food habits. Therefore, many traditional food items have been replaced by new foods that are high energy dense and higher in fat.

It is observed that the prevalence of obesity and overweight was high among the adolescent females although energy intake was lower than the estimated average requirement. This may be due to many factors, such as underreporting and lack of interest of the subjects. On the other hand, the level of physical activity was very low and most of the adolescents' activities were limited to sleeping and seated activities, which may have a negative effect on body weight.

CHAPTER SEVEN: MENSTRUAL CYCLE AND ENERGY BALANCE

This chapter details the results obtained from a study conducted in association with the energy metabolism research group (Head Prof. CJK Henry).

Due to severe restriction on the nature and type of studies that could be undertaken in the UAE it was decided to conduct the last part of the study in Oxford. The final study investigated the role of the menstrual cycle on energy balance and body weight.

A major aspect of the study described in this thesis has been the transition from childhood to adulthood. The study also represents the first cross sectional investigation from the United Arab Emirates that has examined growth and development in girls from age 10-19 years.

In order to examine more closely the biological and nutritional changes that occur after puberty, this chapter will concentrate on the menstrual cycle, a landmark event in the life history of women.

7.1. Subject selection and recruitment

Seven undergraduate and postgraduate students, aged 19-28 years, were recruited through advertisements at Oxford Brookes University. The criteria in choosing the participating subjects were their willingness to participate in the study. They were all naturally cycling non-contraceptive pill users with regular menstrual cycles.

Ethical approval for this study was obtained from the Ethics Committee at Oxford Brookes University.

7.2. Methods

Two phases were studied, firstly the menses or "early follicular" phase (from day 1 of the menstrual cycle) and secondly, the "early luteal" phase (from day 20 of the menstrual cycle). The study duration for each phase was 5 consecutive days.
During the study period, the following measurements were taken each day:

1. Body weight
2. Fat mass and lean body mass (FFM) using Bioelectrical impedance analysis

3. BMR using the Deltatrac metabolic monitor.

Biceps, triceps, subscapilar and suprailiac skinfold thickness were measured once during each phase. In addition, energy and nutrient intakes were estimated each day.

7.2.1. Bioelectrical Impedance Analysis (BIA)

Fat mass (FM) and fat free mass (FFM) were measured by bioelectrical impedance analysis (BIA) using Bodystat® 1500 (Bodystat LTD, Douglas, Isle of Man, UK). BIA is a complete analysis of body fat and fat free mass, measuring fat, lean mass and water in the body (Heyward, 1998).

Subjects were asked to avoid eating or drinking 4 to 5 hours, or exercising 12 hours before measurement and to be normally hydrated. Subjects were asked to lie down in the supine position with their arms and legs spread slightly. Socks and shoes on the right foot were removed. Electrodes were attached to the right hand and right foot; red leads were connected behind the finger and toe on the right hand and foot; black leads were connected to electrodes on the right wrist and right ankle. Age, gender, weight, height and activity were entered into the machine and a reading taken.

7.2.2. Triceps, biceps, subscapular and suprailiac skinfold thickness

A Holtain Skinfold Calliper was used to measure skinfold thickness. For details on TSF measurement see section 3.2.3. For the biceps skinfold thickness, measurements were taken at the front part of the non-dominant upper arm, opposite the triceps skinfold. A pinch of skin and fat was grasped between the thumb and the forefinger and a reading was taken within 2-3 seconds (Cameron, 1984). For the subscapular skinfold thickness, subjects were asked to stand upright during the measurement with their back to the researcher. The area measured was below the inferior angle of the scapula (Cameron, 1984). For the suprailiac skinfold thickness, subjects were asked to face the researcher with their arm by their sides. The area measured was in the mid midaxilliary line superior to the iliac crest (Gibson, 1990). Three measurements were taken and the average value was recorded in millimetres.

Total body fat was estimated from the sum of the four skinfold measurements

using the Durnin and Womersley (1974) equations.

7.2.3. Measurement of BMR

BMR was measured by indirect calorimetry using a Deltatrac metabolic monitor (Deltatrac, Datex-Ohmeda Instrumentarium Corp., Helsinki, Finland), a ventilated hood measurement system. The Deltatrac monitor was calibrated each morning, before measurements were taken, with a reference gas mixture of oxygen-carbon dioxide (95:5, by volume). An alcohol check was performed every 3-6 months.

Measurements were performed in standardized conditions: (1) early in the morning, before breakfast (after a 12-h fast); (2) subjects were lying down; (3) subjects were at complete physical rest in a thermoneutral environment (24-26°C); (4) subjects were awake; and (5) subjects were without disease or fever. Subjects were asked to lie down on a bed for a 10-minute rest period to acclimatise to the canopy and instrument noise.

BMR was measured by calculating heat production from the respiratory oxygen consumed and carbon dioxide produced. To collect the respiratory gases, a transparent Perspex canopy was placed over the subject's head and attached with a plastic sheet fixed around the subject to prevent leaks. Data was collected for 20 minutes; the volume of oxygen consumed, carbon dioxide produced, RQ, and EE were given each minute during this time. The average was then calculated.

7.2.4. Food, energy and macronutrient intakes.

Subjects were provided with all food and drink for the duration of the study. Subjects were asked to choose their meals from an extensive meal selection of hot and cold foods; snack foods and drinks were also available throughout the day. Food items were weighed by the researcher before consumption. Leftovers were also weighed to determine the amount of food consumed. All meals were eaten in the university; breakfast was served after the anthropometric and BMR measurements were taken; lunch and dinner were served at times convenient for the subjects.

Subjects were also asked to record everything they ate/drank in a food diary. If any food/drink was consumed in between meals and not selected from those available,

these were recorded, in the food diary using household measures.

The amount of each food item eaten was entered into a dietary analysis computer program. Results for four nutrients were determined, energy, protein, carbohydrate and fat, for each day using the DIET5 for Windows dietary analysis computer program (The Robert Gordon University, Aberdeen)

.

7.2.5. Estimation of energy expenditure

The factorial method was used to calculate EE. As the major components of EE are BMR and physical activity, the equation was expressed as:

EE=BMR X physical activity level (PAL)

The following formula was used to estimate EB:

EB= EI - EE

Using data from one subject, an example of the calculation is shown below.

Subject 1

BMR= 5518 kJ (follicular phase)

BMR= 5414 kJ (Luteal phase)

EI = 9471 kJ (follicular phase)

EI = 7509 kJ (Luteal phase)

PAL= Proposed 1.64 for moderate active women (Torun *et al.* 1996).

EE (follicular phase)= 5520 x 1.64 = 9050 kJ/day

EB (follicular phase)= 9471- 9050 = + 421 kJ/day

EE (luteal phase)= 5414 x 1.64 = 8879 kJ/day

EB (luteal phase)= 7509-8879= -1370 kJ/day

7.3. Adolescence

Adolescence links the childhood period to adulthood and is a stage of maturation, describing the period from the beginning of puberty to maturity. Puberty is defined as the period in which the secondary sex characteristics begin to develop. It is characterized by a growth spurt, body composition changes and sexual development of primary and secondary sex characteristics (Mitchell, 1997).

Puberty begins at different times for girls and boys; puberty age starts at age 8-

14 years for girls and age 9-14 years for boys. The most widely used sexual maturity rating was developed by Tanner (1962) using pubic hair and breast size in girls and testicular volume in boys (Blondell *et al.* 1999). Table 7.1 shows the 5 pubertal stages in girls.

Table 7.1: Pubertal stages in girls.

Tanner stage	Breasts	Pubic hair	Growth	Other
1	Elevation of papilla only	Villus hair only	Basal: 5-6 cm/year	Ovarian growth
2	Breast bud appears (11.2 yrs)	Sparse growth of slightly pigmented hair	Accelerated: 7-8 cm/year	
3	Breast tissue grows (12.4 yrs)	Hair coarser, curled and pigmented	Peak velocity: 8 cm/year	
4	Projection of areola (13.1 yrs)	Adult-type hair	Deceleration: <7.0 cm/year	**Menarche (13.3 yrs) Regular menses (13.9 yrs)**
5	Adult breast (14.5 yrs)	Adult-type hair with spread medial thigh	Cessation at about 16 years	Adult genitallia

Source: Blondell *et al.* (1999).

7.3.1. Menstrual cycle

Puberty in females is marked by the first experience of menstrual bleeding, which is called "menarche". The average age of the first menstruation varies between countries. In this study, the mean reported first menstruation in the UAE was 12.8 years. Table 7.2 shows the age of menarche in different countries.

Table 7.2: Age at menarche in different countries

Country	Reference	Average age	Range
Australia	Morabia *et al.* (1998)	13	11-15
Bahrain	Musaiger (1998b)	13	9-19
Britain	Whincup *et al.* (2001)	12.9	10-16
Egypt	Attalah *et al.* (1978)	12.6-13.9	-
Jordan	Hasan *et al.* (2001)	11.5	-
Kenya	Morabia *et al.* (1998)	15	13-16
Nigeria	Morabia *et al.* (1998)	15	13-18
Oman	Musaiger (1991)	13.3	-
Saudi Arabia	Musaiger (1998b)	12.9	-
Sudan	Attalah *et al.* (1983)	13.4-14.1	-
USA	Tanner (1990)	12.8	-

The ovaries, hypothalamus and pituitary gland secretions control the menstrual cycle. The hypothalamus secretes gonadotropin-releasing hormone (GnRH) into the hypothalamic portal vessels; GnRH stimulates the pituitary gland to secrete follicle-stimulating hormone (FSH) and luteinizing hormone (LH), which stimulate the ovaries, causing them to secrete progesterone and oestrogen. The length of a typical menstrual cycle is, on average, 28 days and it can be longer (Seeley *et al.* 1999).
The menstrual cycle is divided into four different phases (Buffenstein *et al.* 1995): menses phase (1-4 days); follicular phase (5-11 days); periovulation phase (12-15 days); and the luteal phase (16-28 days).

During the follicular phase the hypothalamus secretion of GnRH stimulates the anterior pituitary gland to release gonadotrpoins (FSH and LH) for the maturation of the ovarian follicle. In turn, the blood levels of oestrogen increase (Herlihy and Maebius, 2000). This phase ends with ovulation and a sharp increase in LH occurs on day 14. In the luteal phase, LH stimulates the corpus luteum to secrete progesterone, which dominates this phase, while FSH and LH secretion are inhibited by progesterone and oestrogen (Sherwood, 2001).

Figure 7.1 illustrates the hormonal changes in menstrual cycle.

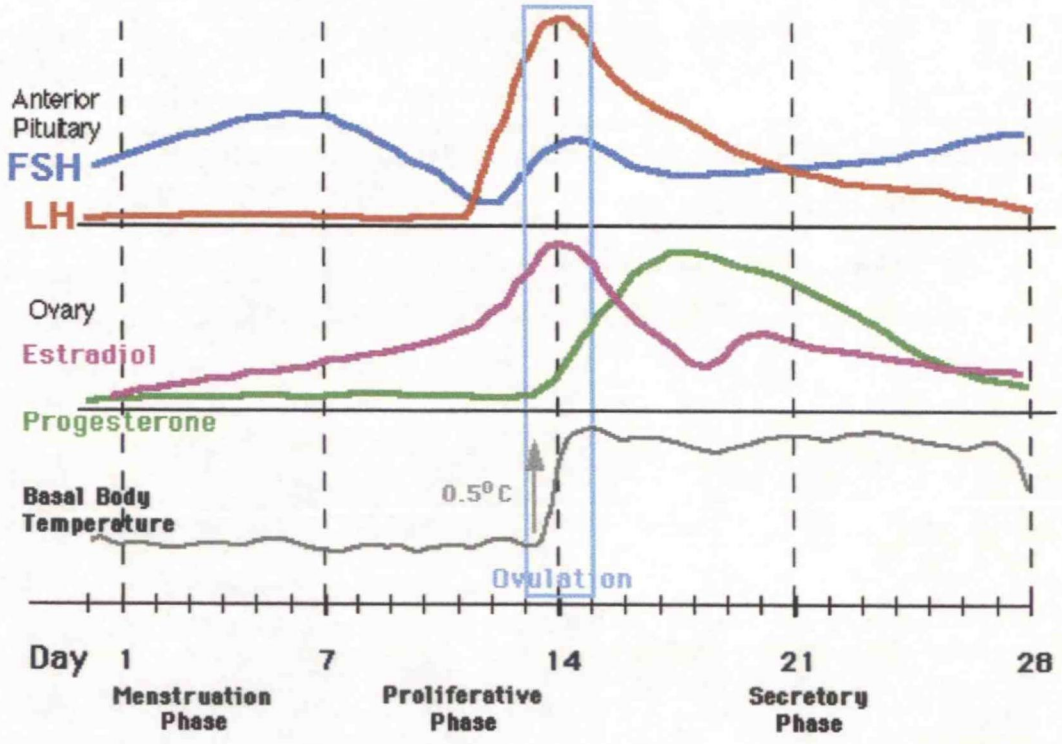

Figure 7.1: Hormonal changes during the menstrual cycle. Source: The University of New South Wales (2001)

7.4. Menstrual cycle and energy balance

Body weight is a function of energy and nutrient balance over an extended period of time (Bouchard, 2000). Three factors-energy intake, energy expenditure (EE) and energy or nutrient partitioning, determine energy balance. Weeks and months of energy imbalance may cause obesity if you are in positive energy balance or underweight if you are in negative energy balance.

The prevalence of obesity is usually higher in women than men - this appears to be universal (James and Ralph, 1999). There is currently no explanation as to why women are more prone to obesity than men. It has been suggested that the variability in basal metabolic rate (BMR) observed in some women during the menstrual cycle might influence energy balance, hence obesity. Although BMR contributes the highest percentage of EE (60-70%) and the menstrual cycle is a unique feature in women, in

this part of the study, the relationship between menstrual cycle and energy balance has been investigated.

Studies in the early 1980s investigated the effect of hormonal changes throughout the different menstrual cycle phases on energy and nutrient intakes. Many aspects were studied such as:

1. Energy expenditure during the menstrual cycle.
2. Changes in energy intake with the menstrual cycle.
3. Changes in macronutrients intake with the menstrual cycle.
4. Macronutrient selection throughout the menstrual cycle phases.

7.4.1. Energy expenditure during the menstrual cycle

Studies to assess the effect of the menstrual cycle on basal metabolic rate were conducted as early as the 1920s. Some of these early results showed that there was no difference in BMR during the menstrual cycle (Blunt and Dye, 1921). However, others showed a characteristic fall in BMR during or immediately after menstruation and a rise in BMR at premenstruation (Wakeham, 1923).

The biphasic changes in BMR were described by Curtis *et al.* (1996) as an increase in the BMR 7-10 days before menstruation (luteal phase) and a sudden drop at the beginning of menstruation (follicular phase), as shown in Figure 7.2.

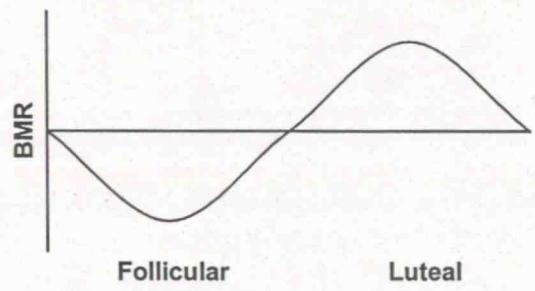

Figure 7.2: Biphasic pattern of BMR during the menstrual cycle

Previous studies have shown that hormonal fluctuations throughout the menstrual cycle affect EE as well as energy intake. Some of these studies found that total energy expenditure is increased in the luteal phase compared to the follicular

phase (Webb, 1986; 2001; Bisdee *et al.* 1989). Other studies have reported a higher BMR (Solomon et al. 1982; Ferraro et al. 1992; Curtis *et al.* 1996) or sleeping metabolic rate (Bisdee *et al.* 1989; Meijer *et al.* 1992), or resting metabolic rate (Pelkman *et al.* 2001) in the luteal phase of the menstrual cycle. Other studies have not reported a significant increase in resting metabolic rate during the luteal phase (Piers *et al.* 1995; Weststrate 1993).

Fluctuation of hormones across the menstrual cycle, mainly progesterone and oestrogen, may affect the EE. The role of progesterone was proposed as a factor in the increase of EE during the luteal phase. In this phase, progesterone increases and it is known as a metabolic stimulant (Webb, 1986). It has the capacity to raise basal body temperature by about 0.4 – 1.4° F and the maximum temperature elevation is achieved during the luteal phase of the menstrual cycle (Landau, 1973). Thus, metabolic rate in all tissues is increased as a result of temperature rise.

7.4.2. Changes in energy intake with the menstrual cycle

Previous studies have shown an increase in energy intake at the luteal phase of the menstrual cycle compared to the follicular phase. The increase in energy intake ranges from 87 kcal to 505 kcal / day (Table 7.3).

As shown in Figure 7.1, the luteal phase is characterized by an increase in progesterone. In animal studies, a decrease in food intake at the follicular phase has been observed and was characterized by an increase in the level of oestrogen, which is believed to be an appetite suppressant (Lyons *et al.* 1989).

Similarly, in humans, it has been suggested that the decrease in food intake (energy) at the follicular phase may be due to the increase in oestrogen concentration at this stage (Manocha *et al.* 1986).

Lissner *et al.* (1988) supported the possibility of hormonal fluctuations, mainly oestrogen, as the cause of a decrease in food intake at the follicular phase compared to the luteal phase. Johnson *et al.* (1994) concluded that variation of energy and fat intake over the menstrual cycle appears to be related to changes in oestrogen/progesterone concentration.

Another possible explanation proposed by Buffenstein *et al.* (1995) is that

progesterone promotes fat storage, resulting in a decrease in plasma triacylglycerols and possibly an increase in the desire to eat fat-rich foods. On the other hand, oestrogen promotes lipolysis resulting in an increase in plasma concentration of fatty acids, which will possibly decrease food intake, especially fat foods.

Table 7.3: Average energy intake during the menstrual cycle

Reference	Luteal phase	Follicular phase	Difference	Significance (P value)
Pelkman *et al.* (2001)	2471 kcal	2374 kcal	+97 kcal	0.021
Li *et al.* (1999)	1669 kcal	1458 kcal	+211 kcal	0.02
Barr *et al.* (1995)	2217 kcal	1916 kcal	+301 kcal	0.0001
Johnson *et al.* (1994)	1876 kcal	1712 kcal	+164 kcal	0.05
Martini *et al.* (1994)	1908 kcal	1749 kcal	+159 kcal	0.003
Fong and Kretsch (1993)	2501 kcal	2360 kcal	+141 kcal	NS
Tarsauk and Beaton (1991)	1912 kcal	1822 kcal	+90 kcal	0.032
Gong *et al.* (1989)	2040 kcal	1833 kcal	+207 kcal	NS
Lyons *et al.* (1989)	2150 kcal	2012 kcal	+138 kcal	NS
Lissner *et al.* (1988)	2335 kcal	2248 kcal	+87 kcal	0.006
Manocha *et al.* (1986)	1620 kcal	1300 kcal	+320 kcal	0.05
	1605 kcal	1300 kcal	+305 kcal	NS
Pliner and Fleming (1983)	2013 kcal	1790 kcal	+223 kcal	0.05
Dalvit (1981)	1935 kcal	1430 kcal	+505 kcal	0.0004
	1945 kcal	1449 kcal	+496 kcal	0.008
Group mean	2157 kcal	1911 kcal	+279 kcal	

NS, not significant

7.4.3. Changes in macronutrient intakes with the menstrual cycle

Variation in macronutrient intake of women during the menstrual cycle has been studied. Dalvit-McPhilips (1983) observed a variation in carbohydrate and fat consumption between the luteal and follicular phases. There was an increase in carbohydrate consumption during the luteal phase compared to the follicular phase, 56-59% and 40-44% respectively. In contrast, there was an increase in the consumption of

fat during the follicular phase compared to the luteal phase, 45-41% and 32-30% respectively (Table 7.4).

Table 7.4: Macronutrient intake during the menstrual cycle (% total energy)

Reference	Luteal phase			Follicular phase		
	Carbohydrate	Protein	Fat	Carbohydrate	Protein	Fat
Pelkman *et al.* (2001)	61	12	27	61	12	27
Li *et al.* (1999)	52	18	31	51	19	29
Barr *et al.* (1995)	56	12	31	58	13	29
Johnson *et al.* (1994)	48	15	37	48	15	36
Martini *et al.* (1994)	50	16	34	51	16	33
Fong and Kretsch (1993)	48	13	42	47	13	42
Tarsauk and Beaton (1991)	46	14	38	47	15	36
Lyons *et al.* (1989)	47	14	36	48	14	35
Dalvit-McPhilips (1983)						
Cycle 1	56	12	32	40	16	45
Cycle 2	59	11	30	44	15	41
Group mean	52	14	34	50	15	35

Johnson *et al.* (1994) reported a significant increase in the amount of fat consumed in the luteal phase compared to the follicular phase, while Martini *et al.* (1994) reported a significant increase in the amount of carbohydrate, protein and fat consumed at the luteal phase, but not expressed as a percentage of total energy.

Dalvit-McPhilips (1983) suggested that the increased carbohydrate consumption following ovulation might also be in response to an increase in BMR to which energy needs to be adjusted. Other studies depend on the results from animal studies, which concluded that oestrogen has a lipolytic action while progesterone promotes fat storage (Johnson *et al.* 1994).

7.4.4. Macronutrient selection throughout menstrual cycle phases

Food cravings also fluctuate throughout the menstrual cycle (Kurzer, 1997) and it has been suggested that women experience greater food cravings, especially for sweet foods, during the luteal phase of the menstrual cycle (Cohen *et al.* 1987; Pliner and Fleming, 1983). Different mechanisms have been proposed. Firstly, menstrual cycle affects taste acuity and it is possible that food preferences may be affected (Tomelleri and Grunewald, 1987). Secondly, food cravings may be due to a lack of specific nutrients in the diet, for example magnesium deficiency has been implicated as a possible causative factor in premenstrual syndrome (Abraham and Lubran, 1981) and it is known that chocolate is fairly a good source of magnesium. Rozin *et al.* (1991) studied the liking and craving for chocolate and found that about half of the females showed a well defined craving peak for chocolate in the premenstrual period, beginning from a few days before the onset of menses to the first few days of menses.

The effect of menstrual cycle on macronutrient and energy intake and energy balance in a group of women aged 19-28 years was investigated.

7.5. Results and discussion

7.5.1. Physical characteristics and anthropometric measurements

The mean age of the subjects was 21.6 (*SD* 3.21) years and mean height was 1.63 (*SD* 0.05). Table 7.5 provides age and height details of the subjects. Table 7.6 shows the anthropmetric data during the follicular and luteal phases.

Table 7.5: Physical characteristics of subjects

Subject	Age (yrs)	Height (m)
1	20	1.56
2	19	1.64
3	23	1.66
4	28	1.66
5	22	1.71
6	19	1.63
7	20	1.61
Group mean	21.6 ± 3.21	1.63 ± 0.05.

individual variation in the present study was CV 6.2%.

7.5.3. Energy intake

The mean results of the food intake data of seven normally cycling females showed a significant fluctuation in energy intake over the menstrual cycle (Table 7.9).

The mean energy intake in this study was significantly higher ($p< 0.05$) in the follicular phase compared to the luteal phase. This is in contrast to previous studies which have shown a significant increase in energy intake in the luteal phase compared to the follicular phase (Dalvit, 1981; Manocha *et al.* 1986; Lissner *et al.* 1988; and Pelkman *et al.* 2001).

Table 7.9: Mean energy intake (kJ/day) during follicular and luteal phase

Subject	Follicular phase			Luteal phase		
	Mean	SD	Range	Mean	SD	Range
1	9471	2591	6362-12637	7509	1941	5223-10463
2	11169	2369	8179-13733	9169	2436	6077-12601
3	23792	9327	16499-39341	18991	3962	13956-23674
4	9085	2189	5636-11693	8006	981	7212-9708
5	6784	1627	4635-9002	6753	1224	5312-8236
6	7193	1806	5501-9095	6651	2111	4907-9931
7	9219	1250	7779-10023	8628	973	7731-9570
Group mean	10959*	5847	6784-23792	9387	4334	6651-18991

Mean±*SD*, significant difference between the 2 phases: * $P<0.05$

The intra-individual variation for energy intake ranged from 11.8-33.7% and the inter-individual variation was 47.5%. The results of this study were consistent with the results of Gong *et al.* (1989), 22.3% and show wide variation in energy intake of the subjects. This variation may be a possible cause of obesity in females as a result of a variation in energy intake during the menstrual cycle phases.

7.5.4. Nutrient intake

The mean results of macronutrient intakes show no significant difference between the menstrual cycle phases (Table 7.10) and are consistent with previous

Table 7.6: Mean anthropometric data at follicular and luteal phases

	Follicular	Luteal
Weight (kg)	56.9±5.16 (50.8-63.4)	56.9±5.10 (51.3-63.2)
BMI (kg/m^2)	21.3±2.6 (18.1-25.9)	21.3±2.5 (18.0-25.5)
Fat (%)	24.4±3.4 (19.5-29.1)	26.1±5.6 (21.5-33.1)
FFM (kg)	42.9±4.2 (38.1-51.0)	42.1±1.9 (38.9-44.9)
BIA (fat%)	21.6±4.7* (15.2-29.2)	22.1±4.6 (15.4-29.0)

Mean±*SD* (range) significant difference between the 2 phases: * $P<0.05$.

There were no significant differences in weight or skinfold thickness; the only significant difference was observed in the percentage body fat measured by BIA, which was higher during the luteal phase. The results of this study are consistent with Manocha *et al.* (1986), Gong *et al.* (1989) and Fong and Kretsch (1993) who found no significant change in body weight during the different phases of the menstrual cycle. In contrast, Pliner and Felming (1983) and Pelkman *et al.* (2001) reported a significant increase of 0.16 kg and 0.3 kg in body weight during the luteal phase compared to the follicular phase respectively.

7.5.2. Basal metabolic rate

Changes in BMR during the menstrual cycle phases were noticed in the early 1920s. In this study, the results showed that there was no significant difference in BMR between the follicular and luteal phases. The results of this study are inconsistent with many studies, which reported a significantly higher BMR in the luteal phase compared with follicular phase of the menstrual cycle (Solomon *et al.* 1982; Ferraro *et al.* 1992). However, Weststrate (1993) and Piers *et al.* (1995) found that there was no significant difference in BMR between the luteal and follicular phases, consistent with the findings of the present study.

Table 7.7: Mean BMR (kJ/day) and BMR/ kg/day during follicular phase

Subject	BMR/day			BMR/kg	
	Mean	SD	Range	Mean	SD
1	5518	123	5400-5690	87.3	2.4
2	5584	219	5310-5820	95.0	3.9
3	6377	789	5820-7280	99.7	11.7
4	6190	0	6190-6190	108.3	0.4
5	5885	479	5300-6320	110.9	9.9
6	5500	403	5060-6020	108.5	9.3
7	5770	298	5520-6100	110.9	5.0
Group mean	5832	342	5500-6377	103.0	9.2

Table 7.8: Mean BMR (kJ/day) and BMR/ kg/day during luteal phase

Subject	BMR/day			BMR/kg	
	Mean	SD	Range	Mean	SD
1	5414	86	5310-5520	87.2	1.2
2	5870	228	5650-6190	97.9	3.7
3	6102	442	5770-6860	96.6	6.6
4	6276	168	6070-6490	109.8	3.2
5	6413	280	6190-6820	123.0	6.2
6	5630	28	5610-5650	109.9	0.2
7	5420	163	5270-5650	104.3	4.2
Group mean	5875	404	5414-6276	104.1	11.6

The level of intra-individual variation was determined by calculating the coefficient of variation (CV) for the measurement period. The CV ranged between 2 – 8.9%. The results of this present study are consistent with the results of Curtis *et al.* (1996); Piers *et al.* (1995) and Weststrate (1993), which showed a mean CV% of 3.45, 7.6 and 6.0 respectively. In this study, the intra-individual variation in BMR in two subjects was similar to that observed in men (2-4%) (Henry *et al.* 1989). The inter-

studies (Pelkman *et al.* 2001; Barr *et al.* 1995).

Table 7.10: Mean carbohydrate, protein and fat intake (% of total energy)

Subjects	Follicular phase			Luteal phase		
	Carbohydrate	Protein	Fat	Carbohydrate	Protein	Fat
1	57	12**	29	54	16	30
2	58	12	28	55	14	31
3	59	14	28	56	12	31
4	65	13	16	68	12	14
5	54	11*	35	45	14	41
6	51*	11	29	61	12	25
7	50	14	35	53	13	29
Group mean	56.3±5.2	12.4±1.3	28.6±6.3	56.0±7.1	13.3±1.5	28.7±8.1

Mean±*SD*, significant difference between the 2 phases: * $P<0.05$, ** $P<0.01$.

Three subjects showed a significant increase in protein and carbohydrate consumption in the luteal phase compared to the follicular phase. The increase in carbohydrate consumption during the luteal phase was consistent with the results of Dalvit-McPhilips (1983) as shown in Table 7.4. However, none of the previous studies showed a significant increase in protein intake in the luteal phase compared to the follicular phase.

Some earlier studies have shown a significant increase in one or more macronutrient intakes in the luteal phase compared to the follicular phase. Dalvit-McPhilips (1983) reported a significant increase in carbohydrate consumption. Martini *et al.* (1994) reported a significant increase in the amount of carbohydrate, protein and fat consumed in the luteal phase compared to the follicular phase. Conversely, Fong and Kretsch (1993) reported a significant increase in the amount of carbohydrate in the menses phase. Some earlier studies reported a significant increase in fat consumption (Tarsauk and Beaton 1991; Johnson *et al.* 1994). The possible explanation of the increase in fat consumption proposed by Johnson *et al.* (1994) was the changes in oestrogen/progesterone ratio throughout the menstrual cycle and the effect on BMR and fat metabolism. In humans, Jones *et al.* (1988) studied the effect of the menstrual

cycle on plasma lipids and found that the follicular phase was characterized by higher mean plasma cholesterol compared to the luteal phase and also high triglycerides and low high density lipoprotein (HDL-cholesterol). This fluctuation in serum lipids may be sensed by the central receptors which regulate fat intake, thus, according to the ratio of the two hormones, could decrease or increase the palatability of fat (Johnson *et al.* 1994). In the present study, fat consumption varied between the subjects - from 16-35% of total energy in the follicular phase to 14-41% of total energy in the luteal phase. This could be due to the ratio of the two hormones, which may decrease or increase the palatability of fat.

Since detailed information on BMR, EI, and EE was available in these subjects, uniquely it was possible to calculate the energy balance (EB) (EB = EI – EE). This is shown in table 7.11.

Table 7.11: Mean BMR, EI, EE and EB of subjects (kJ/day)

Subjects	Follicular phase				Luteal phase			
	BMR	EI	EE	EB	BMR	EI	EE	EB
1	5518	9471	9050	+421	5414	7509	8879	-1370
2	5584	11169	9158	+2011	5870	9169	9627	-459
3	6377	23792	10458	+13334	6102	18991	10007	+8984
4	6190	9085	10152	-1067	6276	8006	10293	-2287
5	5885	6784	9651	-2867	6413	6753	10517	-3764
6	5500	7193	9020	-1827	5630	6651	9233	-2582
7	5770	9219	9463	-359	5420	8628	8889	-261
Group mean	5832 ±342	10959* ±5847	9565 ±561	1378* ±5501	5875 ±404	9387 ±4334	9635 ±663	-248 ±4253

Mean±*SD*, significant difference between the 2 phases: * $P<0.05$.

It has been suggested that variation in energy expenditure may be due to the menstrual cycle and the fluctuation of hormones. The results of this study are inconsistent with the results of previous studies, which showed a significant decrease in energy expenditure in the follicular phase compared to the luteal phase (Webb, 1986; Solomon *et al.* 1982). In the present study, there was no significant difference in BMR between the luteal and follicular phases. In this study, the follicular phase showed a positive energy balance and it is significantly higher than the energy balance

in the luteal phase. On the other hand, the luteal phase shows a negative energy balance.

It is evident that from this brief study certain women are in excessive positive energy balance both during the follicular and luteal phases. Therefore, if such a positive energy balance is maintained through out the menstrual cycle it is likely that these women will become obese.

These preliminary results strongly suggest the importance of understanding the relationship between BMR, EI and EB during the menstrual cycle. An understanding of this relationship will enable us to appreciate (and if necessary intervene) why women are more prone than men to become obese.

CHAPTER EIGHT: LIMITATIONS OF THE PRESENT STUDY AND SUMMARY

A number of limitations to this research have been identified.

1. **Cultural restrictions**: The rules of religion and modesty precluded the girls from being measured in the conventional anthropometric sites, such as subscapular and suprailiac skinfold thickness, waist and hip circumferences. This clearly limited the ability to precisely estimate body composition and fat patterning in these subjects. It was also not possible to make any measurement of basal metabolic rate in these young children and adolescents due to the lack of equipment and reluctance of the subjects to participate in any "invasive" studies.
2. **Nature of the study**. This is the first study of its kind performed in the UAE. Poor appreciation and understanding of the study precluded greater involvement by all the schoolgirls. Notably, poor compliance was observed in the study related to food intake and physical activity.
3. **Limitations of time**: The schooldays are crowded with various lessons. It was very difficult to obtain permission to remove students from these sessions to perform the questionnaire and the anthropometric measurements. The physical exercise lessons were the only time allocated for these measurements. Therefore, time was a major limitation in this study.
4. **Financial support**: This study was not financially supported by any organization; hence the choice of methods used was limited. For example, weighed food record may have been the most optimum method to estimate food intake if weighing scales were available. Similarly, stable isotope studies would be the best choice to estimate energy expenditure in these subjects.

Summary

The prevalence of overweight and obesity in children and adolescents is increasing in the Western countries. However, little is known about the prevalence of overweight and obesity among adolescents in the United Arab Emirates (UAE).

This is the first study performed in the UAE on the prevalence of overweight and obesity in adolescent females. Furthermore, an important aspect of this present study is the inclusion of five Emirates. Previous studies on the prevalence of overweight and obesity have concentrated on one Emirate only - the five Emirates in the present study represent the highest residence of population in the UAE.

The UAE has undergone a rapid change in socio-economic status. This change may affect many aspects in the life of the UAE. This study examined the effect that this change may have on the prevalence of overweight/obesity, food habits, nutrient/energy intake and physical activity of adolescent females in the UAE.

The results showed a high prevalence of overweight and obesity in the UAE. Adolescent females also showed low levels of physical activity - most of the adolescents' activity was limited to sleeping and sitting activities. In particular, the group of adolescents at age 11-14 years showed:

1. A high prevalence of overweight and obesity in terms of body mass index compared to the other age groups. In addition, triceps skinfold thickness was higher in this group.
2. Their energy intake at the weekend was similar to that in the age group 15-17 years, despite having lower energy requirement. This clearly influences their energy balance; furthermore they also have a low level of physical activity which may contribute to being in positive energy balance. This level of positive energy balance is exacerbated by their long hot summer holiday of three months.
3. The number of television viewing hours was significantly higher in this group during schooldays compared to the age group 15-17 years.

The high prevalence of overweight and obesity in this group may be due to many factors, notably high dependence on the housemaids, consumption of snack foods of high energy density and difficulties in undertaking physical exercise due to

cultural and weather conditions.

Almost all females in the UAE will get married at an early age and will be expected to have children. It is a tradition to have large families (Table 4.1), therefore many pregnancies may occur. Pregnancy is often an important event in the weight gain history of women (Bray, 1999) and some women gain a considerable amount of weight during pregnancy. Therefore, being obese at this age (11-14 years) with the possibility of pregnancies even at this age may increase their risk of developing obesity and the prevalence of obesity in this community.

An effective method to control overweight and obesity may be to concentrate on energy intake and energy expenditure in adolescents. In addition, families and schools should work together to achieve this.

Finally, recommendations that may help in the prevention of obesity in the UAE include:

1. Encouragement and targeting of physical exercise exclusively for females.
2. Advice and guidance on the methods of food preparation and cooking.
3. Regulations on the foods to be sold in the schools in the break-time between lessons (especially high fat/sugar snacks and drinks).
4. Decrease the number of hours spent sleeping and in sitting activities by encouraging participation in different kinds of activities to increase energy expenditure.
5. Enhanced nutritional education at all levels of schooling in order to encourage children and adolescents to eat a healthy diet and increase their physical activity.
6. Promotion of exercise and games suitable for the cultural and weather norms of women in the UAE.
7. Encourage greater appreciation of traditional foods in order to minimize the current trend to only consume western type of foods.
8. Promotion of health education to enable the population of the UAE to be aware of the health risks of obesity.
9. Finally encouragement of family centred educational programmes to

enable all members of the family to be aware of the role of diet and exercise in the well being of the community.

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APPENDICES

Appendix 2.1: Methods commonly used in estimation of body composition

Method and procedure	Advantages	Limitations
Hydrostatic Weighing (HW) Subject is weighed in air and then totally submerged in water for at least 10 seconds. The displaced water is measured and body density is calculated.	-Relatively inexpensive. -Quick and easy -Suitable for adults and adolescents.	-Not suitable for infants, children, elderly, physically disabled and those frightened of water. -Affected by menstrual cycle, illness and medications. -Not suitable for patients who suffer from diseases depends on relative water content.
Total Body Potassium (TBP) Total body potassium is measured by ^{40}K counting in a well-shielded environment for approximately 5-10 minutes. On the assumption that there is a constant ratio of potassium per kilogram of fat free mass, TBP can be used to calculate FFM.	- Can be used in all ages and sizes.	-Not suitable for patients with K^+ wasting conditions (uses of diuretics and vomiting). -Expensive

Appendix 2.1 (continued)

Air Displacement Plethsymograph (Bod Pod) Subject is immersed in a closed air-filled chamber. Computerised sensors are used to measure how much air is displaced while a person sits for <5 minutes in the capsule. Body density is determined to estimate body fat and FFM.	-Quick. -Convenient. -Requires minimal compliance. -Suitable for elderly, obese, children and those uncomfortable with water.	-Expensive - Requires special training to operate the instrument. - Can't be used in the subjects with too much hair.
Dual-Energy-X-Ray Absorptiometry (DXA) Subject is scanned with photons at 2 different energy levels and the differential absorption of the photons is measured. Bone mineral calcium, fat and lean tissue can be measured. This measurement takes between 10-70 minutes.	-Measures the % region fat	-Subjects must be absolutely quiet during scanning. -Expensive. -Subject must lie on a table, which may not be suitable for the obese and patients with back problems. -Unsuitable for children and pregnant women.

Appendix 2.1 (continued)

Bioelectrical Impedance Analysis (BIA) Measures the impedance (resistance) to a high frequency electrical current. Adipose tissue yields high impedance because it contains 20% water while muscles contain 75% and yield low impedance.	-Rapid. -Safe. -Non-invasive. -Can be done at bedside.	-Influenced by body water (oedema, ascites). -Influenced by food intake.
Magnetic Resonance Imaging (MRI) The subject is exposed to a magnetic field, which stimulates water and fat molecules in the body, producing measurable signal. It draws organ size, muscle, fat, fat distribution and total body fat. This measurement takes approximately 30 minutes.	-Absence of exposure to non-ionising radiation. - Non-invasive.	-Very expensive. -Complexity of measure.

Appendix 2.1(continued)

Computed Tomography (CT) An x-ray beam is scanned from a source rotating around the subject and passes through them. It provides a visual image of adipose tissue and non-fat tissue within the entire sections of the body. The procedure takes 10 seconds.	-Quick	-Expensive -Exposure to ionising radiation restricts the use in pregnant and children.
Total Body Water (TBW) The measurement of body water by isotope dilution is used to predict lean body mass, which contains 75% water. It is measured using radioactive water $^{3}H2O$ by injection or drinking. The concentration of isotopes in two-body fluids blood, urine, or saliva is measured. This measurement takes approximately 3 hours.	- Little co-operation is needed.	-Involves radiation, so it is not suitable for pregnant women and children. -Water content of FFM increases during obesity and wasting diseases. - Expensive.

Appendix 2.1 (continued)

Neutron Activation Analysis (NAA) Involves irradiating an individual with neutrons to change some of the body's nitrogen, chloride and calcium to radioactive isotopes whose decay can then be measured. It is possible to measure the total body nitrogen (major component of FFM).		-Expensive -Radiation.
Infra Red Interactance (IRA) This technique is still in the development stage. Involves transmission of electromagnetic radiation.		-Radiation but very low levels
Urinary Creatinine Excretion (UCE) Measures the skeletal muscle mass.		-Influenced by diet. -Co-operation is needed. - Laboratory analysis is needed

Appendix 2.1(continued)

Total Body Electrical Conductivity (TOBEC) Subject is placed into a chamber, which generates on electrical current. This measures fat free mass.	-Rapid. -Safe. -Comfortable and non-invasive -Can be used in children, obese subjects and pregnant women.	

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Appendix 3.1: Ethical approval from the Ministry of Health in the United Arab Emirates

UNITED ARAB EMIRATES
MINISTRY OF HEALTH
AL- AIN MEDICAL DISTRICT

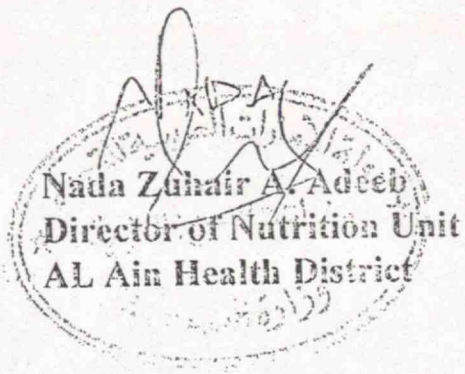
بسم الله الرحمن الرحيم

دولة الإمارات العربية المتحدة
وزارة الصحة
منطقة العين الطبية

TO WHOM IT MAY CONCERN

This is to certify that the practical work followed by miss Huda M. Al Hourani , of the United Arab Emirates University - Al Ain , in Pursual of her graduate Studies in Nutrition , comply to the ethical norms of this region.

This letter is issued to her request.



جامعة الإمارات العربية المتحدة

كلية العلوم الزراعية

قسم علوم الغذاء والتغذية

Appendix 3:2: The study questionnaire

العادات الغذائية عند طالبات المدارس

أولا": معلومات عامة

١. الأمارة: (١) أبو ظبي (٢ دبي (٣) الشارقة (٤) عجمان (٥) الفجيره (٦) أم القويين (٧) راس الخيمة

٢. الصف:----------

٣. تاريخ الولادة: --/--/----

٤. الجنسية: (١) إمارتيه (٢) غير إمارتيه (-------)

٥. المستوى التعليمي للام: (١) أميه (٢) تقرا وتكتب (٣) ابتدائي (٤) إعدادي (٥) ثانوي (٦) دبلوم/جامعي

٦. المستوى التعليمي للأب: (١) أمي (٢) يقرا ويكتب (٣) ابتدائي (٤) إعدادي (٥) ثانوي (٦) دبلوم/جامعي

٧. مهنة ألام: ----------

٨. مهنة الأب: ----------

٩. عدد أفراد الأسرة: --------

١٠. هل يوجد لديكم خدم؟: (١) نعم (٢) لا

إذا كانت الإجابة نعم العدد: -----

١١. هل يوجد لديكم سيارة؟: (١) نعم (٢) لا

إذا كانت الإجابة نعم العدد: -----

ثانيا": معلومات غذائية

١. هل تتناولين إفطارك يوميا"؟

(١) يوميا" (٢) أحيانا" (٣) لا

إذا كانت الإجابة أحيانا" أو لا، كم عدد المرات أسبوعيا" -----

٢. هل تتناولين غدائك يوميا"؟

(١) يوميا" (٢) أحيانا" (٣) لا

إذا كانت الإجابة أحيانا أو لا، كم عدد المرات أسبوعيا" -----

٣. هل تتناولين عشائك يوميا"؟

(١) يوميا" (٢) أحيانا" (٣) لا

إذا كانت الإجابة أحيانا أو لا، كم عدد المرات أسبوعيا" -----

٤. هل تتناولين الطعام بين الوجبات؟

(١) نعم (٢) لا

إذا كانت الإجابة نعم:

(١) فاكهة (٢) حلوى وشوكولاته (٣) قهوة

(٤) شاي بالسكر (٥) مشروبات غازية (٦) فوشار

(٧) ساندويتشا (٨) رقائق البطاطس (٩) آس كريم

(١٠) مكسرات (١١) عصير الفاكهة (١٢) غير ذلك---

٥. ما مدى سرعتك في الأكل؟

(١) سريعة جدا" (٢) متوسطة السرعة (٣) بطيئة

٦. كم عدد المرات التي تتناولين فيها الأطعمة التالية:

	مرة يوميا"	١-٣ مرات أسبوعيا"	٤-٦ مرات أسبوعيا"	مرة شهريا"	مرتين شهريا"	٣ مرات شهريا"	نادرا" أو لا أتناوله إطلاقا"
المشروبات الغازية							
عصير الفاكهة							
الشاي بالسكر							
الحليب							
الايس كريم							
البيتزا							
البرجر							
ساندويتش الجبن							
رقائق البطاطس							
الشوكولاته							
البسكويت والكيك							
المكسرات							
الخضراوات والفاكهة							

ثالثا": معلومات صحية

١. هل بدأت الدورة الشهرية عندك؟ (١) نعم (٢) لا

إذا كانت الإجابة نعم حددي عمرك عند بدؤها -----

٢. هل تعاني من أحد الأمراض التالية، أو أخبرك الطبيب بإصابتك بأحد الأمراض التالية:

(١) السكري (١) نعم (٢) لا

(٢) ارتفاع ضغط الدم (١) نعم (٢) لا

٣. هل يعاني أحد الوالدين من الأمراض التالية:

الأب:

(١) السكري (١) نعم (٢) لا (٣) لا اعرف

(٢) ارتفاع ضغط الدم (١) نعم (٢) لا (٣) لا اعرف

الام:

(١) السكري (١) نعم (٢) لا (٣) لا اعرف

(٢) ارتفاع ضغط الدم (١) نعم (٢) لا (٣) لا اعرف

رابعا": نمط الحياة

١. هل تشاهدين التلفزيون؟

(١) نعم (٢) أحيانا" (٣) لا

إذا كانت الإجابة نعم أو أحيانا"، كم ساعة يوميا" -----

٢. هل تتناولين طعاما" خلال مشاهدتك للتلفزيون؟

(١) نعم (٢) أحيانا" (٣) لا

إذا كانت الإجابة نعم أو أحيانا، ما هو نوع الطعام الذي تتناولينه

------ ------ ------ ------ ------ ------

٣. هل تمارسين الرياضة؟

(١) نعم (٢) لا

إذا كانت الإجابة نعم:

(١) المشي (٢) الركض (٣) السباحة

(٤) التمارين الرياضية (٥) غير ذلك -----

٤. هل تقومين بأحد الأعمال المنزلية؟

(١) نعم (٢) لا

إذا كانت الإجابة نعم:

(١) غسيل الأطباق (٢) تنظيف الغبار (٣) الطهي

(٤) كي الملابس (٥) استعمال المكنسة الكهربائية (٦) غير ذلك ----

خامسا": القياسات الجسمية

	١	٢	٣
وزن الجسم (كغم)			
الطول (سم)			
محيط الذراع (سم)			
سماكة الدهن فوق العضلة ثلاثية الرأس (مم)			
سماكة الدهن فوق العضلة ثنائية الرأس (مم)			
سماكة الدهن تحت لوح الكتف(مم)			
سماكة الدهن فوق عظم الحوض (مم)			
محيط الخصر (سم)			
محيط الأرداف (سم)			

سادسا": النشاطات اليومية

اذكري الوقت المستغرق تقريبا" في ممارسة الأعمال التالية:

الوضوء ---------- دقيقة

الصلوات الخمسة----------دقيقة

تناول وجبة الفطور----------دقيقة

تناول وجبة الغداء----------دقيقة

تناول وجبة العشاء----------دقيقة

التحدث بالتليفون----------دقيقة

التسوق----------دقيقة

الوصول للمدرسة(تحديد وسيلة النقل)----دقيقة

العودة من المدرسة(تحديد وسيلة النقل)----دقيقة

أداء الواجبات المدرسية اليومية--------دقيقة

النوم ليلا" وفي النهار (إن وجد)--------ساعة

مشاهدة التلفزيون----------ساعة

ممارسة الأعمال المنزلية (إن وجدت):

النوع	الزمن
----	----
----	----
----	----

قراءة الصحف والمجلات ----------دقيقة

ممارسة إحدى الهوايات (إن وجدت):

النوع	الزمن
----	----
----	----
----	----

Appendix 3:3: Food frequency questionnaire.

معدل استهلاك الأطعمة التالية:

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية							
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
الخبز والحبوب:										
خبز ابيض	¼ خبزه									
خبز اسمر	¼ خبزه									
صمون	واحدة									
خبز برغر	واحدة									
خبز سلايس	واحدة									
خبز رقاق	-----									
خبز جباب	-----									
أنواع خبز اخرى	-----									

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية								
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
----------	-----									
بسكويت	واحدة									
كعك (نوعه)-----	-----									
أرز مطبوخ	٨ ملاعق									
بيتزا	قطعه									
معكرونة مطبوخة	٨ ملاعق									
كورن فليكس	½ كوب									
رقائق البطاطس	-----									
شعير يه	-----									
الخضراوات:										

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية							
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
الورقية:خس وبقدونس ونعناع وملوخية وجرجير	----- ----- -----									
الجذرية:جزر وبطاطس وشمندر	----- -----									
أخرى:بامية وفاصوليا وفطر وكوسة	----- ----- -----									
الفاكهة:										
تفاح	حبة									
موز	½ واحدة									

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية							
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
مانجا	½ واحدة									
برتقال	واحدة									
دراق	واحدة									
كمثرى	واحدة									
تمر	٣ حبات									
مشمش	٤ حبات									
كيوي	واحدة									
عنب	١٥ حبة									
فراولة	١٢ حبة									
بطيخ	شريحة									
عصير فاكهة	كوب									

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية							
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
أنواع أخرى----- -----	----- -----									
اللحوم:										
الضأن(الخروف)	-----									
العجل	-----									
الدجاج	-----									
السمك(نوعه)----	-----									
الكبد والكلاوي	-----									
برغر	قطعة									
ربيان	-----									
السجق(نقانق)	-----									

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية							
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
البيض	واحدة									
حمص أو فول	-----									
الحليب ومنتجاته:										
حليب سائل	كوب									
لبن	كوب									
روب	كوب									
حليب بودرة-----	-----									
لبنه	٣ملاعق									
جبنه-----	-----									
ايس كريم	كوب									

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية							
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
الزيوت والدهون:										
زبده	ملعقة شاي									
زيت-------	ملعقة شاي									
زيتون	١٠ حبات									
مكسرات:										
لوز	----									
جوز	----									
كاجو	----									
فول سوداني	----									

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية								
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
بندق	----									
بذور	----									
المشروبات:										
قهوة	فنجان									
شاي	كوب									
نسكا فيه	كوب									
كاكاو	كوب									
مشروبات غازية:بيبسى أو ما شابه	علبه									
عصير فاكهة صناعي	كوب									

الطعام	الكمية	معدل استهلاكها خلال ال١٢ شهرا" الماضية								
		لا أتناوله إطلاقا"	١-٣ مرات شهريا"	مرة أسبوعيا"	٢-٤ مرات أسبوعيا"	٥-٦ مرات أسبوعيا"	مرة يوميا"	٢-٣ مرات يوميا"	٤-٥ مرات يوميا"	اكثر من ٦ مرات يوميا"
مشروبات أخرى	-----									
الحلويات:										
السكر	ملعقة									
مربى	ملعقة									
عسل	ملعقة									
شوكولاته------	قطعة									
حلويات أخرى	-----									
----------	-----									
----------	-----									

Appendix 3.4: Food diary sheet

مفكرة طعام

الإسم: التاريخ: اليوم :

الطعام	الساعة	الكمية	ملاحظات
الفطور			
مابين الفطور و الغداء			
الغداء			
مابين الغداء و العشاء			
العشاء			
قبل النوم			

Appendix 3.5: Example of energy and nutrient intakes calculation using DIET5

Diet5 for Windows, The Robert Gordon University, Aberdeen

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USDA Release 12, 1998.

05-19-2001 13:11:30

Day 1--Breakfast

49	100	White bread, sliced
1198	30	haloom cheese
1196	5	Tea, black, infusion, weak
1011	10	Sugar, white

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
White bread,	49	100	926	1.3	0.3	E3	1.5	7.6	0.2	
haloom chees	1198	30	458	8.7	N0	N0	N0	4.9	N0	
Tea, black,	1196	5	0	T0	T0	E0	0	0	T0	
Sugar, white	1011	10	168	0	0	E10.5	0	T0	0	
Totals			1552	10	0.3	13.5	1.5	12.6	0.2	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
White bread,	49	100	0.05	3.1	17	0	0	100	1.4
haloom chees	1198	30	N0	N0	N0	N0	N0	246	0.4
Tea, black,	1196	5	0	0	0	0	0	T0	T0
Sugar, white	1011	10	0	0	0	0	0	0	T0
Totals			0.05	3.1	17	0	0	346	1.8

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
White bread,	49	100	79	20	530	99	0.5	0.4	0
haloom chees	1198	30	N0	N0	N0	N0	N0	N0	N0
Tea, black,	1196	5	0	0	T0	1	T0	T0	0
Sugar, white	1011	10	T0	T0	T0	0	0	0	0
Totals			79	20	530	100	0.5	0.4	0

Day 1--Morning snack

1037	30	Potato crisps
1020	30	Kit Kat

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Potato crisp	1037	30	683	11.3	2.8	E0.2	1.5	1.7	0.03	
Kit Kat	1020	30	628	8	4.1	E14	N0	2.5	0.03	

Totals			1310	19.3	6.9	14.3	1.5	4.1	0.07

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Potato crisp	1037	30	0.02	1.8	12	8.1	0	11	0.5
Kit Kat	1020	30	0.13	0.9	N0	0	2	60	0.4
Totals			0.15	2.7	12	8.1	2	71	1

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Potato crisp	1037	30	36	14	321	318	0.2	3	0
Kit Kat	1020	30	57	16	33	99	0.3	0.5	T0
Totals			93	29	354	417	0.5	3.4	0

Day 1--Lunch

23	120	White rice, easy cook, boiled
1191	90	Sandwich burger

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
White rice,	23	120	704	1.6	0.4	E0	0.1	3.1	0.01	
Sandwich bur	1191	90	2237	7.7	N0	N0	N0	9.9	N0	
Totals			2941	9.3	0.4	0	0.1	13	0.01	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
White rice,	23	120	T0	1.8	5	0	0	22	0.2
Sandwich bur	1191	90	N0	N0	N0	N0	5	25	2.1
Totals			0	1.8	5	0	5	47	2.3

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
White rice,	23	120	65	13	1	65	0.8	0.6	0
Sandwich bur	1191	90	N0	N0	N0	N0	N0	N0	N0
Totals			65	13	1	65	0.8	0.6	0

Day 1--Afternoon snack

1080	250	Coca-cola
1037	30	Potato crisps
1196	5	Tea, black, infusion, weak
1011	10	Sugar, white

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Coca-cola	1080	250	420	0	0	E26.3	0	T0	0	
Potato crisp	1037	30	683	11.3	2.8	E0.2	1.5	1.7	0.03	
Tea, black,	1196	5	0	T0	T0	E0	0	0	T0	

Sugar, white	1011	10	168	0	0	E10.5	0	T0	0
Totals			1271	11.3	2.8	37	1.5	1.7	0.03

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Coca-cola	1080	250	0	0	0	0	0	10	T0
Potato crisp	1037	30	0.02	1.8	12	8.1	0	11	0.5
Tea, black,	1196	5	0	0	0	0	0	T0	T0
Sugar, white	1011	10	0	0	0	0	0	0	T0
Totals			0.02	1.8	12	8.1	0	21	0.5

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Coca-cola	1080	250	38	3	20	3	T0	0	0
Potato crisp	1037	30	36	14	321	318	0.2	3	0
Tea, black,	1196	5	0	0	T0	1	T0	T0	0
Sugar, white	1011	10	T0	T0	T0	0	0	0	0
Totals			74	16	341	322	0.2	3	0

Day 1--Evening meal

1199 100 Harees
1196 5 Tea, black, infusion, weak
1011 10 Sugar, white

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Harees	1199	100	318	1.5	N0	N0	N0	5.1	N0	
Tea, black,	1196	5	0	T0	T0	E0	0	0	T0	
Sugar, white	1011	10	168	0	0	E10.5	0	T0	0	
Totals			486	1.5	0	10.5	0	5.1	0	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Harees	1199	100	N0	N0	N0	N0	7	31	1.2
Tea, black,	1196	5	0	0	0	0	0	T0	T0
Sugar, white	1011	10	0	0	0	0	0	0	T0
Totals			0	0	0	0	7	31	1.2

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Harees	1199	100	N0	N0	N0	N0	N0	N0	N0
Tea, black,	1196	5	0	0	T0	1	T0	T0	0
Sugar, white	1011	10	T0	T0	T0	0	0	0	0
Totals			0	0	0	1	0	0	0

Day 1--Evening snack

1080 1037 Coca-cola
1037 30 Potato crisps

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Coca-cola	1080	1037	1742	0	0	E108.9	0	T0	0	
Potato crisp	1037	30	683	11.3	2.8	E0.2	1.5	1.7	0.03	
Totals			2425	11.3	2.8	109.1	1.5	1.7	0.03	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Coca-cola	1080	1037	0	0	0	0	0	41	T0
Potato crisp	1037	30	0.02	1.8	12	8.1	0	11	0.5
Totals			0.02	1.8	12	8.1	0	53	0.5

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Coca-cola	1080	1037	156	10	83	10	T0	0	0
Potato crisp	1037	30	36	14	321	318	0.2	3	0
Totals			192	24	404	328	0.2	3	0

Totals for day1

Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
9984	62.6	13.1	184.3	6	38.2	0.34	

Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
0.25	11.1	59	24.3	15	569	7.3

P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
502	102	1630	1233	2.4	10.4	0

Day 2--Breakfast

49 100 White bread, sliced
189 250 Whole milk
293 40 Eggs, chicken, boiled

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
White bread,	49	100	926	1.3	0.3	E3	1.5	7.6	0.2	
Whole milk	189	250	688	9.8	6	E0	0	8	0.07	
Eggs, chicke	293	40	245	4.3	1.2	E0	0	5	0.03	
Totals			1858	15.4	7.5	3	1.5	20.6	0.3	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
White bread,	49	100	0.05	3.1	17	0	0	100	1.4
Whole milk	189	250	0.43	2	15	2.5	138	288	0.1
Eggs, chicke	293	40	0.14	1.5	16	0	76	23	0.8
Totals			0.62	6.6	48	2.5	214	410	2.3

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
White bread,	49	100	79	20	530	99	0.5	0.4	0
Whole milk	189	250	230	28	138	350	1	0.3	1
Eggs, chicke	293	40	80	5	56	52	0.5	0.5	0.44
Totals			389	52	724	501	2	1.1	1.44

Day 2--Morning snack

23 90 White rice, easy cook, boiled

439 90 Chicken, roast, meat + skin

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
White rice,	23	90	528	1.2	0.3	E0	0.1	2.3	0.01	
Chicken, roa	439	90	812	12.6	3.8	E0	0	20.3	N0	
Totals			1340	13.8	4	0	0.1	22.7	0.01	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
White rice,	23	90	T0	1.4	4	0	0	16	0.2
Chicken, roa	439	90	N0	I3.8	N0	0	T0	8	0.7
Totals			0	5.1	4	0	0	24	0.9

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
White rice,	23	90	49	10	1	49	0.6	0.4	0
Chicken, roa	439	90	153	19	65	243	1.3	2.3	T0
Totals			202	29	66	292	1.9	2.7	0

Day 2--Lunch

1196 5 Tea, black, infusion, weak

1011 10 Sugar, white

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Tea, black,	1196	5	0	T0	T0	E0	0	0	T0	
Sugar, white	1011	10	168	0	0	E10.5	0	T0	0	
Totals			168	0	0	10.5	0	0	0	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Tea, black,	1196	5	0	0	0	0	0	T0	T0
Sugar, white	1011	10	0	0	0	0	0	0	T0
Totals			0	0	0	0	0	0	0

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Tea, black,	1196	5	0	0	T0	1	T0	T0	0
Sugar, white	1011	10	T0	T0	T0	0	0	0	0
Totals			0	0	0	1	0	0	0

Day 2--Afternoon snack

23 90 White rice, easy cook, boiled

439 60 Chicken, roast, meat + skin

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
White rice,	23	90	528	1.2	0.3	E0	0.1	2.3	0.01	
Chicken, roa	439	60	541	8.4	2.5	E0	0	13.6	N0	
Totals			1070	9.6	2.8	0	0.1	15.9	0.01	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
White rice,	23	90	T0	1.4	4	0	0	16	0.2
Chicken, roa	439	60	N0	I2.5	N0	0	T0	5	0.5
Totals			0	3.9	4	0	0	22	0.7

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
White rice,	23	90	49	10	1	49	0.6	0.4	0
Chicken, roa	439	60	102	13	43	162	0.8	1.5	T0
Totals			151	23	44	211	1.5	2	0

Totals for day2

Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
4436	38.7	14.4	13.5	1.7	59.2	0.32	

Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
0.62	15.6	55	2.5	214	456	3.9

P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
741	104	833	1004	5.4	5.8	1.44

Day 3--Breakfast

189 250 Whole milk
1190 50 sandwich cheese

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Whole milk	189	250	688	9.8	6	E0	0	8	0.07	
sandwich che	1190	50	612	4.3	N0	N0	N0	7.1	N0	
Totals			1299	14.1	6	0	0	15.1	0.07	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Whole milk	189	250	0.43	2	15	2.5	138	288	0.1
sandwich che	1190	50	N0	N0	N0	N0	49	126	0.9
Totals			0.43	2	15	2.5	186	414	1

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Whole milk	189	250	230	28	138	350	1	0.3	1
sandwich che	1190	50	N0	N0	N0	N0	N0	N0	N0
Totals			230	28	138	350	1	0.3	1

Day 3--Morning snack

1080 1037 Coca-cola
1037 30 Potato crisps

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Coca-cola	1080	1037	1742	0	0	E108.9	0	T0	0	
Potato crisp	1037	30	683	11.3	2.8	E0.2	1.5	1.7	0.03	
Totals			2425	11.3	2.8	109.1	1.5	1.7	0.03	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Coca-cola	1080	1037	0	0	0	0	0	41	T0
Potato crisp	1037	30	0.02	1.8	12	8.1	0	11	0.5
Totals			0.02	1.8	12	8.1	0	53	0.5

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Coca-cola	1080	1037	156	10	83	10	T0	0	0
Potato crisp	1037	30	36	14	321	318	0.2	3	0
Totals			192	24	404	328	0.2	3	0

Day 3--Lunch

23	120	White rice, easy cook, boiled
1194	90	fried fish
1192	50	Salad, green

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
White rice,	23	120	704	1.6	0.4	E0	0.1	3.1	0.01	
fried fish	1194	90	794	11.7	N0	N0	N0	21.3	N0	
Salad, green	1192	50	26	0.2	T0	E0.9	0.5	0.3	0.03	
Totals			1524	13.4	0.4	0.9	0.6	24.8	0.04	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
White rice,	23	120	T0	1.8	5	0	0	22	0.2
fried fish	1194	90	N0	N0	N0	N0	35	38	1.2
Salad, green	1192	50	0	0.2	15	18	16	10	0.2
Totals			0	1.9	19	18	51	69	1.6

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
White rice,	23	120	65	13	1	65	0.8	0.6	0
fried fish	1194	90	N0	N0	N0	N0	N0	N0	N0
Salad, green	1192	50	17	4	3	80	0.1	0.1	0
Totals			81	17	4	145	0.9	0.7	0

Day 3--Afternoon snack

856	100	Apples, eating, raw

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Apples, eati	856	100	199	0.1	T0	E0	1.8	0.4	0.03	
Totals			199	0.1	0	0	1.8	0.4	0.03	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Apples, eati	856	100	0.02	0.2	1	6	3	4	0.1
Totals			0.02	0.2	1	6	3	4	0.1

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Apples, eati	856	100	11	5	3	120	0.1	0.1	0
Totals			11	5	3	120	0.1	0.1	0

Day 3--Evening meal

1190 50 sandwich cheese
1196 5 Tea, black, infusion, weak
1011 15 Sugar, white

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
sandwich che	1190	50	612	4.3	N0	N0	N0	7.1	N0	
Tea, black,	1196	5	0	T0	T0	E0	0	0	T0	
Sugar, white	1011	15	252	0	0	E15.8	0	T0	0	
Totals			864	4.3	0	15.8	0	7.1	0	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
sandwich che	1190	50	N0	N0	N0	N0	49	126	0.9
Tea, black,	1196	5	0	0	0	0	0	T0	T0
Sugar, white	1011	15	0	0	0	0	0	0	T0
Totals			0	0	0	0	49	126	0.9

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
sandwich che	1190	50	N0	N0	N0	N0	N0	N0	N0
Tea, black,	1196	5	0	0	T0	1	T0	T0	0
Sugar, white	1011	15	T0	T0	T0	0	0	0	0
Totals			0	0	0	1	0	0	0

Day 3--Evening snack

1080 250 Coca-cola
1020 30 Kit Kat

	Code	Wt	Energ kJ	Fat g	SFA g	NMES g	g	NSP g	Prot mg	Thiam
Coca-cola	1080	250	420	0	0	E26.3	0	T0	0	
Kit Kat	1020	30	628	8	4.1	E14	N0	2.5	0.03	
Totals			1048	8	4.1	40.3	0	2.5	0.03	

	Code	Wt	Ribof mg	Niac mg	Fol ug	VitC mg	VitA ug	Ca mg	Fe mg
Coca-cola	1080	250	0	0	0	0	0	10	T0
Kit Kat	1020	30	0.13	0.9	N0	0	2	60	0.4
Totals			0.13	0.9	0	0	2	70	0.4

	Code	Wt	P mg	Mg mg	Na mg	K mg	Zn mg	PUFA g	B12 ug
Coca-cola	1080	250	38	3	20	3	T0	0	0
Kit Kat	1020	30	57	16	33	99	0.3	0.5	T0
Totals			95	18	53	102	0.3	0.5	0

Totals for day3

Energ	Fat	SFA	NMES		NSP	Prot	Thiam
kJ	g	g	g	g	g	mg	
7358	51.2	13.3	166	3.9	51.5	0.21	

Ribof	Niac	Fol	VitC	VitA	Ca	Fe
mg	mg	ug	mg	ug	mg	mg
0.6	6.8	48	34.6	291	735	4.6

P	Mg	Na	K	Zn	PUFA	B12
mg	mg	mg	mg	mg	g	ug
608	91	602	1046	2.6	4.4	1

DRVs are for 11-14F, averages for week with 3 days

NUTRIENT		AMT	DRV	%DRV	
Energ	kJ	7259	7920	91	Estimated Average Requirement
Fat	g	50.9	75	67	
SFA	g	13.6	23.5	57	
NMES		g	121.3	54	224
NSP	g	3.9	18	21	
Prot	g	49.6	41.2	120	Reference Nutrient Intake
Thiam	mg	0.29	0.7	41	Reference Nutrient Intake
Ribof	mg	0.49	1.1	44	Reference Nutrient Intake
Niac	mg	11.2	12	93	Reference Nutrient Intake
Fol	ug	54	200	27	Reference Nutrient Intake
VitC	mg	20.5	35	58	Reference Nutrient Intake
VitA	ug	173	600	28	Reference Nutrient Intake
Ca	mg	587	800	73	Reference Nutrient Intake
Fe	mg	5.3	14.8	35	Reference Nutrient Intake
P	mg	617	625	98	Reference Nutrient Intake
Mg	mg	99	280	35	Reference Nutrient Intake
Na	mg	1022	1600	63	Reference Nutrient Intake
K	mg	1094	3100	35	Reference Nutrient Intake
Zn	mg	3.4	9	37	Reference Nutrient Intake
PUFA	g	6.9	13.9	49	
B12	ug	0.81	1.2	67	Reference Nutrient Intake

Averages for meals	1	2	3	4	5	6
Energ(kJ)	1570	1692	1544	846	450	1157
Fat (g)	13.2	14.8	7.6	7	1.9	6.4
SFA (g)	4.6	4.6	0.2	1.9	0	2.3
NMES (g)	5.5	41.1	3.8	12.3	8.8	49.8
NSP (g)	1	1	0.2	1.1	0	0.5
Prot (g)	16.1	9.5	12.6	6	4.1	1.4
Thiam(mg)	0.19	0.04	0.02	0.02	0	0.02
Ribof(mg)	0.36	0.06	0	0.01	0	0.05

Niac (mg)		3.9	3.2	1.3	1.9	0	0.9
Fol (ug)		27	9	8	6	0	4
VitC (mg)		1.7	5.4	6	4.7	0	2.7
VitA (ug)		133	1	19	1	19	1
Ca (mg)		390	49	39	16	53	41
Fe (mg)		1.7	0.8	1.3	0.4	0.7	0.3
P (mg)		233	162	49	78	0	95
Mg (mg)		33	27	10	15	0	14
Na (mg)		464	275	2	129	0	152
K (mg)		317	346	70	217	1	143
Zn (mg)		1.2	0.9	0.6	0.6	0	0.2
PUFA (g)		0.6	3	0.4	1.7	0	1.1
B12 (ug)		0.81	0	0	0	0	0

23	140	White rice, easy cook, boiled						
		822	1.8	0.4	E0	0.1	3.6	0.01
		T0	2.1	6	0	0	25	0.3
		76	15	1	76	1	0.7	0
49	66.6	White bread, sliced						
		617	0.9	0.2	E2	1	5.1	0.13
		0.03	2.1	11	0	0	67	0.9
		53	13	353	66	0.3	0.3	0
189	166.6	Whole milk						
		458	6.5	4	E0	0	5.3	0.05
		0.28	1.3	10	1.7	92	192	0.1
		153	18	92	233	0.7	0.2	0.67
293	13.3	Eggs, chicken, boiled						
		82	1.4	0.4	E0	0	1.7	0.01
		0.05	0.5	5	0	25	8	0.3
		27	2	19	17	0.2	0.2	0.15
439	50	Chicken, roast, meat + skin						
		451	7	2.1	E0	0	11.3	N0
		N0	I2.1	N0	0	T0	5	0.4
		85	11	36	135	0.7	1.3	T0
856	33.3	Apples, eating, raw						
		66	0	T0	E0	0.6	0.1	0.01
		0.01	0.1	0	2	1	1	0
		4	2	1	40	0	0	0
1011	18.3	Sugar, white						
		308	0	0	E19.3	0	T0	0
		0	0	0	0	0	0	T0
		T0	T0	T0	0	0	0	0
1020	20	Kit Kat						
		418	5.3	2.8	E9.4	N0	1.6	0.02
		0.09	0.6	N0	0	1	40	0.3

38	10	22	66	0.2	0.3	T0	

1037	40	Potato crisps						
		910	15	3.7	E0.3	2	2.2	0.04
		0.03	2.4	16	10.8	0	15	0.7
		48	18	428	424	0.3	4	0
1080	858	Coca-cola						
		1441	0	0	E90.1	0	T0	0
		0	0	0	0	0	34	T0
		129	9	69	9	T0	0	0
1190	33.3	sandwich cheese						
		408	2.9	N0	N0	N0	4.7	N0
		N0	N0	N0	N0	32	84	0.6
		N0	N0	N0	N0	N0	N0	N0
1191	30	Sandwich burger						
		746	2.6	N0	N0	N0	3.3	N0
		N0	N0	N0	N0	2	8	0.7
		N0	N0	N0	N0	N0	N0	N0
1192	16.6	Salad, green						
		9	0.1	T0	E0.3	0.2	0.1	0.01
		0	0.1	5	6	5	3	0.1
		6	1	1	27	0	0	0
1194	30	fried fish						
		265	3.9	N0	N0	N0	7.1	N0
		N0	N0	N0	N0	12	13	0.4
		N0	N0	N0	N0	N0	N0	N0
1196	8.3	Tea, black, infusion, weak						
		0	T0	T0	E0	0	0	T0
		0	0	0	0	0	T0	T0
		0	0	T0	2	T0	T0	0
1198	10	haloom cheese						
		153	2.9	N0	N0	N0	1.6	N0
		N0	N0	N0	N0	N0	82	0.1
		N0	N0	N0	N0	N0	N0	N0
1199	33.3	Harees						
		106	0.5	N0	N0	N0	1.7	N0
		N0	N0	N0	N0	2	10	0.4
		N0	N0	N0	N0	N0	N0	N0

Appendix 3.6: Dominant activity sheet.

ألإسم :

اليوم: التاريخ:

	١٥دقيقة	١٥دقيقة	١٥دقيقة	١٥دقيقة
السادسة صباحا				
السابعة صباحا				
الثامنة صباحا				
التاسعة صباحا				
العاشرة صباحا				
الحادية عشر صباحا				
الثانية عشر ظهرا				
الواحدة ظهرا				
الثانية مساء				
الثالثة مساء				
الرابعة مساء				
الخامسة مساء				
السادسة مساء				
السابعة مساء				
الثامنة مساء				
التاسعة مساء				
العاشرة مساء				
الحادية عشر مساء				
الثانية عشر مساء				
الواحدة صباحا				
الثانية صباحا				
الثالثة صباحا				
الرابعة صباحا				
الخامسة صباحا				

Appendix 3.7: Example of PAL calculation using DIET5

Diet5 for Windows, The Robert Gordon University, Aberdeen
The Nutrient Databank is Crown copyright and has been reproduced under licence from the Controller of Her Majesty's Stationery Office.
USDA Release 12, 1998.
05-22-2001 10:54:36
40.6 kg, 12 years,

	mins	time %	energy %
1	600	41	31
2	540	37	34
3	150	10	12
4	30	2	3
5	120	8	17
6	0	0	0
7	0	0	0
8	0	0	0

Formula for BMR = (56 X 40.6) + 2898 = 5171.6
Energy requirement: 5171.6 X 1.31 = 6776 kJ

Appendix 6.1: Summary of previous studies estimating energy and nutrient intakes of adolescents

Author/Year	**Country**	**Method**	**Age (yrs)**	**Sex**	**N**	**Energy (MJ)**	**%Protein**	**%Fat**	**%CHO**
Anderson *et al.* (1995)	Norway	Quantitative FFQ	18	M and F	1564	M = 15.8 MJ F = 9.9 MJ	NA	31.0	NA
Dura (2001)	Spain	Semi quantitative FFQ	13-16	M and F	406	NA	15	44	42
Hassapidou & Fotiadou (2001)	Greece	Three days weighed records	11-14	M and F	582	M = 11.5 MJ F = 9.7 MJ	M = 15 F = 15	M = 41 F = 44	M = 47 F = 44
Rasanen *et al.* (1991)	Finland	48 hour recall	9-24	M and F	1200	NA	15	38	47
Samuelson *et al.* (1996)	Sweden	FFQ and weighed 7-day record	15	M and F	411	M = 10.0 MJ F = 7.9 MJ	NA	NA	NA
Cole *et al.* (1997)	Nigeria	Weighed records	11-17	F	22	6.5 MJ	13	28	59
Decarli *et al.* (2000)	Switzerland	3-day record	11-16	M and F	NA	M = 9.4 MJ F = 8.0 MJ	14	37	49

Females (F), males (M), number (N), not available (NA), Mega joule (MJ), and carbohydrates (CHO)