Physical activity and obesity in Lebanese adolescents: prevalences, measurements and associations

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ACTIVITÉ PHYSIQUE ET OBÉSITÉ CHEZ LES ADOLESCENTS LIBANAIS: PRÉVALENCES, MESURES ET ASSOCIATIONS

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Dedication

To my wife, for everything

To my father and mother, for their sacrifice and patience

To my sister, for her love and support

To my friends for their constant support and unquestionable belief

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OUTLINE

PART 2: PERSONAL CONTRIBUTION

PART 3: APPENDIX

List of Abbreviations

ADP	Air Displacement Plethysmography
BF	Body Fat Mass
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
CT	Computer Tomography
DXA	Dual Energy X-ray Absorptiometry
FFM	Fat-Free Mass
HRQOL	Health Related Quality of Life
MRI	Magnetic Resonance Imaging
PA	Physical Activity
TBW	Total Body Water
%BF	Percent Body Fat

INTRODUCTION

Obesity is a complex and multidimensional condition that is caused by the interaction of several factors. In general, it is accepted that increases in bodyweight that lead to obesity are caused primarily by a disruption of the balance between energy intake and energy expenditure. In other words, a marked reduction in physical activity accompanied with diets rich in fats and simple sugars are considered two of the most important contributing factors.

Research shows that the prevalence of obesity is on the rise among adults and children in developed and developing countries. Studies also show that obesity is associated with the onset of disease and premature death. On the other hand, increasing physical activity level has demonstrated benefit against the co-morbidities of obesity. However, obese individuals generally have low physical activity levels as their bodyweight poses an extra burden on movement. A further understanding of this relation may significantly contribute to solving the issue of hazardous weight gain.

In Lebanon, an Asian republic located at the East end of the Mediterranean, research on obesity is still in its early stages. However, evidence suggests that obesity is following the same trend as in developed countries.

This thesis addresses the ever increasing problem of adolescent obesity. It is divided into two parts. In part 1, the first chapter covers all aspects of obesity ranging from assessment and prevalence to causes and consequences. The second chapter defines physical activity and discusses issues related to assessment, patterns and trends, quality and quantity, in addition to the role of physical activity in the development of obesity. In part II, the author provides his personal contribution through a series of studies that deal with BMI-defined overweight and obesity among Lebanese adolescents in relation to physical activity, inactivity, quality of life, and body fat levels.

PART 1: REVIEW OF LITERATURE

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1. Obesity

The existence of obesity has long been with humanity. Ever since the Stone Age, our ancestors left us with valuable drawings which depicted massive cases of obesity [Bray, 1990]. About 2000 years ago, Hippocrates observed that death and illness is more common in those who are naturally fat than in the lean [Bain, 2006].

Around the 1950s, few reports dealing with public health concerns and weight status appeared [Jaret, 1986; Breslow, 2006]. However, it was not until 1985 where the National Institutes of Health held a Consensus Development Conference and issued a formal conclusion linking obesity to undesired health risks [Burton and Foster, 1985].

Perhaps the rise of obesity was masked by the public health concern of cigarette smoking and lung cancer which emerged during the same period [Breslow 2006], and thus resulted in a delay in realizing the issue of obesity.

.1.1. Definition

Nowadays, various statements exist for the definition of obesity. However, most would agree to the medical description stating that obesity is a condition characterized by an unusually high proportion of body fat (BF), which is associated with an increased risk of developing many medical disorders and possibly leading to reduced life expectancy. Simply defined, obesity is a pathological excess of BF [Haslam and James, 2005].

.1.2. Assessment

Based on the definition of obesity, there is a need to determine exactly how much fat is considered as excess. Therefore, accurate methods of measuring BF are essential in obesity research. In recent years, various techniques have been developed for the estimation of fat and fat free mass. They are classified as reference or field methods with each having its advantages and disadvantages.

.1.2.1. Reference Methods

Several methods for measuring body composition have been described through the literature. These include underwater weighing (densitometry) and air displacement plethysmography (ADP), Dual energy X-ray absorptiometry (DXA), Dilution method (hydrometry), magnetic resonance imaging (MRI) and computer tomography (CT). These methods are highly accurate and can provide valuable information concerning the distribution of fat within the body. In fact, BF distribution has been associated with an increased risk of developing certain diseases, irrespective of its amount [Vague, 1956]. Reference methods are not suitable for epidemiological studies and large scale screening because of their high cost, limited accessibility and technical complexity. Therefore, their use has proved to be significant in the validation of other more simple methods of measuring BF [Ashwell et al., 1985].

.1.2.1.1. Densitometry and Air-Displacement Plethysmography

Densitometry involves the accurate measurement of bodyweight both in air and underwater. Body mass is then divided by body volume to find out the total body density, which is used to estimate body composition through the use of prediction equations [Siri, 1993; Brozek, 1963]. This requires the knowledge of the specific densities of fat and fat-free mass (FFM). The disadvantage of this process is that the density of FFM may be influenced by several factors such as age, gender, and ethnicity [Lohman, 1986]. Moreover, another concern is the need to adjust for residual lung volume. Failure to do so may result in significant methodological inaccuracy [Heymsfield, 1998]. For these reasons, the use of densitometry is not recommended in children, elderly, and obese subjects.

Current advances have provided the ADP. This new technique utilizes a machine known as the BodPod. It replaces water with air and may be of more practical use since it is less invasive [Dempster P et al., 1995]. However, more recently, in some studies, ADP has been shown to underestimate %BF in children and adolescents as compared to DXA measurements [Lazzer et al., 2008; Lockner et al., 2000]

.1.2.1.2. Dual Energy X-ray Absortiometry

The DXA is based on the principle that the two x-ray beams are diluted differently by bone mineral, soft tissue, fat tissue and FFM. Initially invented for the diagnosis of osteoporosis, its use has quickly spread. It is now one of the most reliable methods for assessing whole body composition as well as local measurements of bone mass, lean mass and fat mass [Mazess et al., 1990; Ley et al., 1992]. Moreover, DXA measurements have been verified by comparison with chemical analysis of animal cadavers [Pintauro et al., 1996; Svendsen et al., 1993] and studies have reported high long term reproducibility of DXA measurements (Hologic QDR 4500A absorptiometer) [Cordero-MacIntyre et al., 2002]. However, the use of different models and differences in calibration procedures and software application may lead to considerable variations in body composition results [Tothill et al., 1994 a; Tothill et al., 1994 b; Schoeller et al., 2005]. Based on this, comparison or interpretation of results obtained from different machines or with varying software applications should be done with caution.

In addition to the above mentioned complications, DXA has some other limitations [Tataranni and Ravussin, 1995], such as the size of the scanning area which may not accommodate morbidly obese subjects and its inability to differentiate subcutaneous adipose tissue from intra-abdominal adipose tissue [Goran et al., 1998] which is extremely important when investigating the relation of these two parameters with the health risks of obesity. Despite this, its accuracy, noninvasive approach, quick scan time (<20min), and low radiation dose make it a highly recommended method for measuring body composition.

.1.2.1.3. Hydrometry

This technique is based on the use of isotopes, specifically deuterium, tritium, and oxygen-18-labelled water, to measure total body water (TBW). Based on the assumption that the proportion of body water to FFM is stable at 0.73, TBW is calculated using validated equations depending on the degree of the dilution of the isotope by total body fluid. Then, FFM is determined as TBW/0.73 and total BF is derived from the difference between bodyweight and FFM [Schoeller 2005].

Although this technique is valuable in measuring the body composition of individuals with morbid obesity, the assumption of a constant ratio of TBW to FFM has been questioned in these subjects [Schoeller 2005]. Moreover, it has been shown that this ratio may also be influenced by several health conditions such as obesity, immunodeficiency syndrome, chronic renal failure, edema with malnutrition, and sepsis.

.1.2.1.4. Magnetic Resonance Imaging and Computer Tomography

These are considered the most accurate methods for assessing body composition and determining the distribution of fat and muscle through high resolution imaging [Ross and Janssen, 2005]. In fact, their accuracy in assessing local fat or muscle content has been validated against human cadavers [Ross and Janssen, 2005].

MRI emits no radiation and, therefore, its use is safe for children and pregnant women. On the other hand, CT is faster and more accurate than MRI in assessing visceral adipose tissue [Seidall et al., 1990]. However, the major disadvantage of CT is the risk of exposure to high radiation as compared to DXA screening. Because of this, some studies have provided evidence of a possibility to significantly reduce the radiation dose [Starck et al., 1998; Starck et al., 2002].

.1.2.2. Field Methods

As with all methods of assessing body composition, these are not without flaws. However their widespread is attributed to their relative simplicity which requires little subject cooperation at a low cost. These methods include: Bioelectrical Impedance analysis (BIA) and anthropometric measurements.

.1.2.2.1. Bioelectrical Impedance Analysis

This technique measures electrical resistance in the body to an imperceptible frequency (50 kHz). It is based on the concept that electricity passes through lean tissue faster than it passes through fat tissue. The reason for that is because lean tissue has a high water content, while fat tissue contains less water therefore conductivity is impeded [Thomasset 1962]. There are two main disadvantages of BIA. The first method gives an estimate of TBW, which must then be converted into FFM. This cannot be done without knowing the hydration of FFM, which is usually constant in adults [Pace et al., 1995] but known to vary in children [Fomon et al., 1982]. Second, this technique should be used carefully with special attention given for electrode placement, subject's body position, hydration status, and skin temperature. Even under ideal conditions BIA tends to over predict BF in lean and athletic subjects [Segal 1996] as well as under predict BF in obese persons [Sun et al., 2005].

A more advanced method, known as bioelectrical impedance spectroscopy, has been developed. It uses multi-frequency currents (50-300 kHz) and divides the body into a series of cylinders. One major difference with the single-frequency BIA is that it separately estimates intracellular water and extracellular water. This new technology may provide more accurate measurements of body composition than single-frequency BIA [Kyle et al., 2004]. However, compared to DXA measurements, it underestimated lean tissue in normal weight subjects and overestimated it in obese subjects [Ward et al., 2007].

.1.2.2.2. Anthropometry

The measurement of physical dimensions of the human body is referred to as Anthropometry. It is the most commonly used method to assess size and body composition. It is inexpensive and noninvasive, and it can provide information about health, physical performance and survival [de Onis and Habicht, 1996]. Anthropometry includes skinfold thickness, circumference measurements, and weight and height based indexes.

.1.2.2.2.1. Skinfold Measurement

Skinfold measurement has been traditionally used to estimate BF. A special caliper is used to measure the thickness of a layer of skin and the underlying fat at certain fixed locations [WHO, 1995]. Then, BF and %BF are estimated using prediction equations. Among these, the equations of Durnin and Womersley [Durnin and Womersley, 1974] used for adults and the Slaughter equation used for children and adolescents [Janz et al., 1993] have been shown to predict BF reasonably well. However, many studies have questioned this approach especially since the skinfold measurement is poorly reproducible and prone to inter user variation [Marks et al., 1989; WHO, 1995]. Moreover, it has been suggested that the errors associated with the estimation of BF via skinfold measurement are significantly higher in obese subjects compared to those in non-obese subjects [Gray et al., 1990]. Recently, a study conducted in obese children and adolescents demonstrated that skinfold measurement is poorly predictive of abdominal and total BF as compared to DXA measurements [Watts et al., 2006].

.1.2.2.2.2. Circumferences

Measuring body Circumferences is simple, cheap and highly reproducible. Research has shown that waist circumference can be self reported with significant accuracy [Rimm et al., 1990]. As mentioned earlier, because BF distribution is independently associated with several diseases [Eckel et al., 2005], the use of circumference measurements may be beneficial, especially, since both waist and hip circumference are good predictors of intra-abdominal fat [Goran et al., 1998]. In addition, waist circumference is significantly associated with cardiovascular diseases [de Koning et al., 2007] and increased mortality [Koster et al., 2008]. Based on this, its use is recommended in the assessment of cardio-metabolic disease risks, where many cut-offs have been developed for this reason [WHO 2000]. Moreover, it has also been suggested that the waist to hip ratio is a useful measure of central obesity and a valid anthropometric index in predicting a wide range of risk factors and related health conditions [Akpinar et al., 2007].

.1.2.2.2.3. Weigh Based Indexes

Body weight especially at very high levels, tends to be associated with BF levels. However, by itself it cannot accurately measure BF, since weight is correlated with height [Troiano and Flegal, 1999]. Based on this, several measures of weight in relation to height were developed. Among these are Benn’s Index, Rohrer’s Index (RI), and the Body Mass Index (BMI).

.1.2.2.2.3.1. Benn’s Index

Benn’s Index is defined as weight (kg)/height ^{p} where the value p which is uncorrelated with height is between 1.18-1.5 for females and 1.65-1.83 for males [Garn and Pesick, 1982]. However, p is calculated using complicated mathematical equations and the index itself is not significantly more accurate than other weight based indexes, therefore this index is rarely used [Chinn et al., 1992; Poskitt, 1995].

.1.2.2.2.3.2. Rohrer's Index

Rohrer's Index is defined as weight (kg)/height^3. Several studies have compared the RI to the BMI in its ability to predict BF levels. One study suggested that RI may be a much better choice than BMI at assessing gender and race-specific risks of adult overweight [Valdez et al., 1996]. Another study found that age specific BMI is better than age specific RI in predicting underweight or overweight in children and adolescents aged 2-19 years [Mei et al., 2002]. However, the use of RI is not as widespread as the BMI.

.1.2.2.2.3.3. Body Mass Index

Defined as weight (kg)/height^2, it was developed in 1835 by Quetelet, a Belgian astronomer. He observed that bodyweight was proportional to the square of the height [Eknoyan 2008]. In 1972, the Quetelet index was termed the BMI in 1972 in a study which reported high correlations between BMI and BF as assessed by skinfold and densitometry [Keys et al., 1972].

BMI is the most commonly used tool for classifying obesity. In adults, cut-off points of 25 kg/m^2 and 30 kg/m^2 have been suggested to determine overweight and obesity, respectively [Garrow and Webster, 1985]. More recently, in 1993, the World Health Organization committee on physical status classified BMI based on the increase in the risk of co-morbidities as follows: 25-29.9 kg/m^2 as overweight (increased risk), 30-34.9 kg/m^2 as obese class one (moderate risk), 35-39.9 kg/m^2 as obese class two (severe risk), and 40 kg/m^2 and above as obesity class three (very severe risk) [WHO 1995].

Defining overweight and obesity in children is more complicated than in adults because weight varies with height as children grow. This process is best described by Horlick in the title of his article, "Measuring a Moving Target" [Horlick 2001]. During maturation, males develop more lean tissue mass than females [Malina 2005]. Although it is highly correlated, BMI is not a direct measure of BF. It can only detect changes in bodyweight [Pietrobelli et al 1998; Goran et al., 1996]. Therefore, the use of cut-off points should be based on age and gender. The earliest published charts of BMI were for French children. The importance of these charts is that they provided an index to compare a child's measurements with those of other children in the same age group and adiposity is estimated using percentile ranges [Rolland-Cachera et al., 1982]. Latter on, data compelled from six different countries were used to develop age and gender specific BMI cut-off points [Cole et al., 2000]. One of the advantages of this study is that it provides a unified definition for child obesity which allows for easy comparison between studies. However, it remains to be seen whether these cut-offs are applicable across different populations.

The association of BMI and mortality in adults has been researched extensively. In fact, the results of a recent meta-analysis of 56 studies found that at a BMI of 30-35 kg/m^2, average survival is reduced by 2-4 years, and at 40-45 kg/m^2 it is reduced by 8-10 years [Whitlock et al., 2009]. In children and adolescents, the relation between BMI and mortality is less pronounced than in adults. However, significant associations have been found between BMI and serious health complications [Dietz and Robinson, 1998]. Moreover, in another study, overweight adolescents had an increased risk of future obesity-related morbidity as compared to their normal weight peers [Must et al., 1992].

Numerous studies have assessed the validity of BMI in predicting BF as measured by criterion methods. Several studies have demonstrated that BMI is highly correlated with both BF mass and %BF in adults [Gallagher et al., 1996; Blew et al., 2002]. Studies conducted in youth report similar results [Goulding et al., 1996]. These findings confirm that BMI is a reliable indicator of BF. Based on this, several equations have been developed to predict BF from BMI for children and adults [Deurenberg et al., 1991; Pongchaiyakul et al., 2005; Pietrobelli et al., 1998]. However, these equations are seldom used.

The relation between BMI and body composition has been shown to be affected by several factors such as ethnicity and body structure [Malina 2005; Deurenberg and Deurenberg, 2001]. Although one previous study reported that despite higher BMI values for African Americans, %BF as assessed by DXA was not significantly different from Caucasians [Gallagher et al., 1996]. A more recent review reported that, for a given BMI, African Americans were found to have lower %BF than Caucasians [Wagner and Heyward, 2000].

The influence of ethnicity is more consistent between Caucasians and Asians. In fact, for a given BMI, the %BF in Asians was found to be higher than in Caucasians [Deurenberg et al., 2002]. Moreover, there is also evidence that the relation between BMI and BF might differ even between sub populations in Asia [Deurenberg et al., 2000]. These differences among adult populations may also exist among children. In fact very recent reports have provided evidence for ethnic influence on this relation among children and adolescents [Navder et al., 2009; Freedman et al., 2008].

Despite certain limitations, BMI is simple and easy to calculate. Its accuracy depends on selecting appropriate cut-off points based on age, gender, and ethnicity. Used by itself or in conjunction with other methods, BMI is considered the method of choice for assessing overweight and obesity in large epidemiological studies.

.1.2.3. Summary

A summary for the commonly used body composition methods is provided in table 1. Available methods have greatly contributed to our understanding of the diverse causes of obesity and its numerous complications. Based on this, success in the prevention or management of obesity depends greatly on the progress of body composition assessment. For this reason, the search for a unified and flawless methodology continues to pose a challenge for all. In the meantime, reference methods, such as Dual-energy X-ray absorptiometry, are highly accurate. However, their expensive cost, technical complexity, and limited availability restrict their use in large scale studies. Field methods may be more suitable alternatives. Of these, the simplest and most widely used is the BMI. Research shows that it is highly correlated with measures of BF, disease incidence, and mortality. However, results using this simple method should be interpreted carefully while taking into account that BMI is an indirect measure of BF that is age-, sex- and ethnicity-specific.

Table1. Characteristics of body composition measuring methods

Method	Description	Advantage	Disadvantage	Application
Densitometry	Weight is measured in air and underwater, BF is then calculated	High accuracy	Burdensome, requires cooperation	Unsuitable for children and older subjects
DXA	Two x-ray beams are diluted differently through various body tissues	High accuracy and reproducibility, low radiation exposure	Costly and importable.	Unsuitable for pregnant women
Hydrometry	Isotopes provide measures of total body water	Noninvasive, simple and safe	Ratio of TBW to FFM may vary.	Morbidly obese patients
MRI & CT	Magnetic resonance of proton to capture images. CT images are created by a computer that interprets X-ray images	Extremely accurate for assessing body composition and fat distribution. MRI has no radiation exposure	Very expensive and not always available, may not accommodate morbidly obese subjects	MRI suitable for pregnant women, infants and elderly
BIA	Measures electrical resistance based on variation of water content in body tissues	Inexpensive, portable, simple.	No standardized prediction equations. affected by several factors	may under-estimate BF in obese subjects
Skinfold thickness	A special caliper is used to measure the thickness of a double layer of skin, equations are used to estimate BF	Inexpensive and relatively simple procedure	Subject to inter-user variations	Not suitable for obese subjects
Circumference measurements	Use of measuring tape to determine circumference of waist and/or hip	Simple. Validated with DXA results	Procedure not entirely standardized	Suitable for all populations
Weight based indexes	Most known is BMI, calculated as weight/height^2	Validated against reference methods	Does not distinguish fat mass from FFM	Less accuracy in older subjects

.1.3. Prevalence of Obesity

Over the past couple of years, rates of overweight and obesity have increased rapidly in many parts of the world. Globally, it is estimated that 1.6 billion adults are overweight and 400 million are obese [WHO 2006]. An even more alarming concern is the high prevalence among children. In fact, it is reported that 155 million are overweight, including at least 30 million obese children [Lobstein et al., 2004].

The prevalence of overweight and obesity does not seem to be confined to more developed countries. Low and middle income countries have also reported increased prevalence [WHO 2006]. In fact, in certain countries, such as Gambia for example, obesity coexists with undernutrition (BMI<18 kg/m^2) [van der Sand et al., 2001]. This condition has been manifested in many countries [Mendez et al., 2005], thus posing a double burden for disease. Moreover, it is estimated that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese [WHO 2006].

.1.3.1. Europe

Prevalence of overweight and obesity among adults in the European Union is 35.9% and 17.2% respectively. It is estimated that more males than females are overweight (BMI 25-29.9). In contrast, a higher rate of obesity is reported among females [IASO 2008]. As seen in table 2, the United Kingdom, Greece, and Lithuania have some of the highest prevalence of obesity, whereas Sweden and Italy have the lowest. However, it is also striking that the prevalence of overweight is elevated among both males (BMI range: 26.0 - 46.2) and females (BMI range: 19.4 - 40.0) in all European countries. In total, the combined prevalence of overweight and obesity among the adult population of the European Union is over 53% [IASO 2008].

Recent reports show high prevalence rates among children in the European Union. For example, in Spain 35% of boys and 32% of girls are overweight. Prevalence among children in Portugal, Greece and England are also among the highest [IASO 2009]. In fact, one study concluded that the number of children who are overweight is expected to rise by 1.3 million children per year, with more than 300,000 of them becoming obese each year. The study also estimated that by 2010, 26 million children in E.U. countries will be overweight, including 6.4 million who will be obese [Kosti and Panagiotakos, 2006].

Table2. Overweight and obesity among adults in the European Union (EU)*

Countries	Males			Females		
	OW	OB	Combined	OW	OB	Combined
UK	42.6	23.2	65.8	31.1	23.2	54.3
Greece	38.7	22.3	61.0	28.1	20.2	48.3
Lithuania	35.5	20.8	56.3	31.7	21.6	53.3
Ireland	46.2	19.3	65.4	31.9	16.0	47.9
France	40.8	15.3	56.2	23.0	17.0	40.0
Sweden	26.0	7.0	32.9	40.0	7.5	47.5
Italy	36.5	7.9	44.4	20.9	8.6	29.5
EU*	42.8	16.2	59	29.5	18.1	47.5

OW: overweight (BMI:25-29.9); OB: obese (BMI:≥30); Combined: OW + OB (BMI≥25)
Modified from the International Association for the Study of Obesity (IASO), July 2008 (www.iotf.org/database/)
* 27 countries excluding Luxembourg and Slovenia

.1.3.2. Americas

Adult obesity in America increased from 12.0% in 1991 to 17.9% in 1998 [Mokdad et al., 1999]. Recent reports show continuous increases in prevalence. In fact in 2006, a study reported that 66.3% and 32.2% of American adults are overweight and obese respectively [Ogden et al., 2006]. In Canada prevalence rates have increased markedly since 1970 Estimates show that 50.7% of Canadian adults are overweight and 14.9% are obese [Katzmarzyk 2002], with more recent studies showing a continued increase [Belanger-Ducharme and Tremblay, 2005]. Other countries have also experienced a rising tide in obesity [Ford and Mokdad, 2008]. For example, in Mexico, the estimated prevalence of obesity is 24.2% in men and 34.5% in women [Olaiz et al., 2006]. In Brazil, 8.8% of men and 13.0% of women were obese in 2003. These figures are higher than those reported in 1975 (2.7% and 7.4% respectively). This suggests an increasing trend in the prevalence of obesity [Monteiro et al, 2007]. Moreover, it has been reported that the combined prevalence of overweight and obesity (BMI $\geq$ 25kg/m^2) is high in several Latin American countries. For example, the combined prevalence is 68% in Paraguay, 60% in Argentine, and 53% in Peru [Filozof et al., 2001].

Among children and adolescents living in the United States, the prevalence of at risk of overweight (BMI for age at 85th percentile or higher) and overweight (BMI for age at 95th percentile or higher) was high with a significant upward trend. The prevalence of overweight in females aged 2-19 years increased from 13.8% in 1999-2000 to 16.0% in 2003-2004. In 2-19 year old males, the prevalence increased from 14.0% to 18.2% [Ogden et al., 2006]. Recently, it was reported that the occurrence of severe obesity (BMI ≥ 99^{th} percentile) among children and adolescents has tripled over the past 25 years [Skelton et al., 2009].

Studies on the prevalence of overweight and obesity in other American countries have also expressed concern. For example, based on national BMI for age cut-off points, the prevalence of overweight and obesity among adolescents in Bolivia is 14.0% and 5.0% respectively [Perez-Cueto et al., 2009]. Among Brazilian children and adolescents, the prevalence of overweight and obesity in males increased from 2.9% in 1974-1975 to 13.1% in 1996-1997, among females, prevalence increased from 5.3% to 14.8% [Wang et al., 2002]. In Canada, overweight and obesity also exhibited increasing trends. The prevalence of overweight among boys increased from 15% in 1981 to 28.8% in 1996 and among girls from 15% to 23.6%. The prevalence of obesity in children more than doubled over that period, from 5% to 13.5% in boys and 11.8% in girls [Tremblay and Willms, 2000]. In 2004, the Canadian Community Health Survey reported that among adolescents aged 12 to 17, overweight has more than doubled and obesity rate has tripled over the past 25 years [Shields 2005].

.1.3.3. Africa

Surprisingly, studies show that some African countries are following the global trend of an increase in the prevalence of overweight and obesity. For example, according to the South Africa Demographic Health Survey, the prevalence of overweight and obesity among men aged fifteen years and older was 21% and 8.8% respectively. Among women, the prevalence was 28% and 27% respectively [SADHS 2003]. A study conducted among 6-13 year old children reported that the prevalence of overweight and obesity among boys was 10.9% and 2.4% respectively, while the prevalence among girls was 17.5% and 4.8%. The study also suggests that these trends are similar to those found in developed countries ten year ago [Armstrong et al., 2006]. Alarming trends are also found in some countries in Northern Africa. For instance, the prevalence of obesity in Morocco and Tunisia was 12.2% and 14.4% respectively. Overweight was prevalent in more than half of the female population in both countries [Mokhtar et al., 2001]. In general, most African countries have very low rates of obesity among children. The prevalence is restricted mostly to the adult population [Prentice 2009].

.1.3.4. Asia

The prevalence of overweight and obesity in Asia demands significant concern, especially since studies have shown that for certain populations the risk of developing medical complications starts to increase at BMI values lower than $25kg/m^2$ [Wen et al., 2009]. Based on universal cut-off points, the combined prevalence of overweight and obesity has increased considerably in many South

Asian countries. In 1996, the overweight-obesity prevalence was 10.6% in India, 1.6% in Nepal, and 2.7% in Bangladesh. In 2006 these rates increased to 14.8%, 10.1%, and 8.9% respectively [Balarajan and Villamor, 2009]. In Malaysia, a study using the National Health Survey data revealed that among adults 20.7% were overweight and 5.8% were obese, and obesity was significantly higher in women [Ismail et al., 2002].

In Far East Asia, obesity is also a public health problem. For example, in Japan, based on the National Nutrition Survey (2000), the prevalence of overweight was 24.5% in males and 17.8% in females, whereas that for obesity was 2.3% in males and 3.4% in females [Yoshiike et al., 2002]. In China, the prevalence of overweight and obesity was 24.1% and 2.8% in men and 26.1% and 5.0% in women, respectively [Reynolds et al., 2007]. However, another study using the World Health Organization recommended cut-off points for Asians (overweight: BMI $\geq$ 23 kg/m^2, Obesity: BMI $\geq$ 27.5 kg/m^2) reported that the prevalence of overweight and obesity among Chinese men was 48.6% and 10.5%, respectively [Lee et al., 2008]. Among children and adolescents, the prevalence in 1985 was less than 0.2% for obesity and between 1% and 2% for overweight. In 1995, the prevalence of overweight increased two to three folds, and the prevalence of obesity was 6%. In 2000, the combined prevalence of overweight and obesity in 7-12 year old Chinese children had exceeded 25% in boys and 14% in girls [Ji et al., 2004].

Data on overweight and obesity in the Eastern Mediterranean is limited. However, reports show elevated prevalence in many countries. In Turkey for example, the prevalence of overweight and obesity was 36.0% and 30.4% respectively [Oguz et al., 2008]. High prevalence was also reported among Iranian adults, 31.8% were overweight and 11.1% of men and 25.2% of women were obese [Janghorbani et al., 2007]. Obesity was detected in 38.2% of Syrian adults [Maziak et al., 2007]. Saudi Arabia reported that overweight was prevalent in 30.7% of men and 28.4% of women, while obesity was prevalent in 14.2% of men and 23.6% of women [Al-Othaimeen et al., 2007]. Studies also show that over 40% of the female adult populations in Kuwait and Qatar are obese [Al Rashdan and Nesef, 2009; Bener and Tewfik, 2006]. The prevalence of overweight among adults in Lebanon was 57.7% in women and 49.4% in men, while 18.8% of women and 14.3% of men were reported as obese [Sibai et al., 2003 a].

A summary of the estimated prevalence of overweight and obesity in most countries of the Middle East is presented in table 3. Obesity is widespread and it is more common among women than men. However, even though these values provide an idea about the prevalence of obesity, calculations were based on international BMI cut-off points which have yet to be assessed for their validity in detecting overweight and obesity among the populations of this region. This is important especially since studies have found that for certain Asian populations, it is recommended that overweight and obesity be defined at lower BMI points [Chang et al., 2003; Deurenberg et al., 2002; Deurenberg et al., 2000].

Table3. Prevalence of adult overweight and obesity in the Middle East*

Country	Men		Women	
	OW	OB	OW	OB
Turkey [Oguz et al., 2008] 20-90 years	41.5	20.6	30.6	39.9
Iran [Janghorbani et al., 2007] 15-65 years	42.8	11.1	57.0	25.2
Lebanon [Sibai et al., 2003] over 20 years	57.7	14.3	49.4	18.8
Syria [Maziak et al., 2007] 18-65 years		28.8		46.4
Saudi Arabia [Al Othaimeen et al ., 2007] Over 18 years	30.7	14.2	28.4	23.6
Kuwait [Al Rahdan & Nesef, 2009] Over 18 years	38.8	39.2	28.9	53
Qatar [Bener & Tewfik, 2006] Over 18 years	34.4	34.6	33	45.3

OW: overweight (BMI: 25-29.9); OB: obese (BMI: ≥30)
*not all countries included

Studies conducted in children and adolescents also show elevated prevalence rates in many countries. In Lebanon for example, a study conducted in 10-18 year olds reported that overweight and obesity prevalence was 24.4% and 7.5% respectively [Chakar and Salameh, 2006]. In Syria, prevalence rates among 15-18 year old adolescents were estimated at 18.9% for overweight and 8.6% for obesity [Nasreddine et al., 2009]. Among Qatari adolescents, the prevalence of overweight and obesity was 28.6% and 7.9% respectively among boys, and 18.9% and 4.7% respectively among girls [Bener 2006]. In Jordan, overweight and obesity prevalence among 6-12 year old children was reported at 19.4% and 5.6% respectively [Khader et al., 2009]. In Kuwait, among 10-14 year old children, 30.7% were overweight and 14.6% were obese [El-Bayoumy et al., 2009]. Among 5-17 year old children living in the United Arab Emirates, 21.5% were overweight and 13.7% were obese [Malik and Bakir, 2007]. In Iran, 17.9% were overweight and 7.1% were obese [Moayeri et al., 2006]. In Turkey, the prevalence of overweight and obesity among 12-17 year old adolescents is 10.6% and 2.1% in girls and 11.3% and 1.6% in boys [Oner et al, 2004].

Even though BMI is commonly used to assess overweight and obesity prevalence among populations, comparing results from different studies is challenging. Several factors should be considered, for example, the use of different BMI cutoff points, whether BMI was based on self report or measured weight and height, is the study sample nationally representative,

.1.3.5. Summary

The increasing prevalence of obesity is clearly visible throughout the world. The countries with the highest prevalence of obesity worldwide are those located in the Western Pacific region. Reports show that the prevalence of obesity is 78.53% in Nauru and 56% in Tonga [Keke et al., 2007; Coyne et al., 2000].

In Europe, more than half of the population is either overweight or obese, and more men than women are overweight. In America, one out of three adults is obese and almost two out of three are overweight, while in neighboring Canadian, almost half of the adult population is reported as overweight. Prevalence in Africa is heterogeneous, with high rates in North Africa. Most other African countries report very low prevalence rates for obesity. However, the co-existence of obesity with undernutrition poses a double burden for disease. In Asia, it has been shown that many adult populations are susceptible to disease at lower BMI values. In general, the prevalence of overweight and obesity is lower than that found in Europe and America. However reports show rapidly increasing trends. In the Middle East, obesity is higher among women. Prevalence rates are not far from those reported among countries in Europe and America. If current trends are not altered, it is estimated that by 2025 the prevalence of adult obesity is expected to exceed 40% in the United States, 30% in England, and 20% in Brazil [Kopelman 2000].

In children, the use of different definitions for obesity, and the lack of nationally representative systematic surveys especially in developing countries limit the ability to assess prevalence and trends in childhood obesity and pose a challenge in comparing rates across populations. Nonetheless, available studies show that pediatric obesity is growing with the highest prevalence reported in Northern America and the lowest found in Africa. The overall global childhood prevalence is estimated at 10% for overweight and 2-3% for obesity [Lobstein et al., 2004].

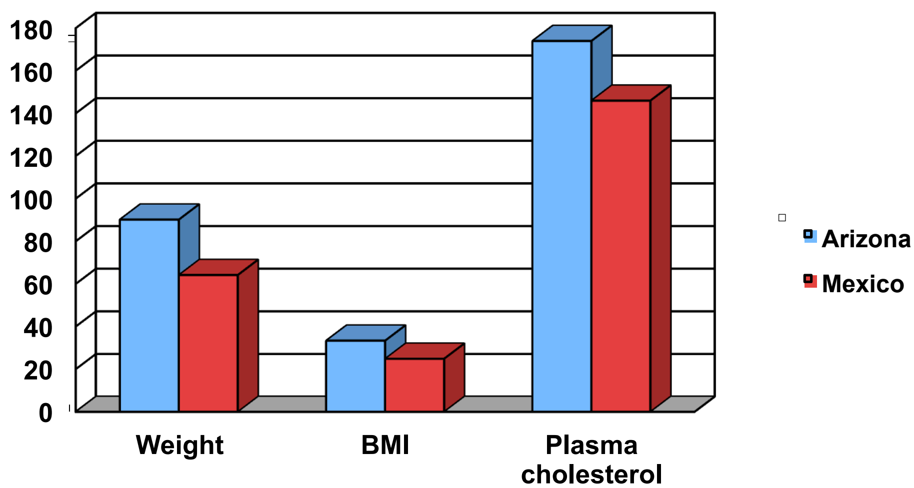
.1.4. Causes of Obesity

Obesity is a global epidemic associated with major health problems. Its suggested causes are numerous and are heavily debated. Environments with an abundance of food and an increasingly sedentary lifestyle may cause a caloric imbalance which favors fat storage. However, it is noticeable that not all people living in these environments will become obese nor will they develop the same medical complications. This variation in how people respond to the same environmental conditions suggests a genetic influence on the development of obesity.

.1.4.1. Genetics

Although it is well established that genetics have a role in the cause of obesity, the degree of their contribution is not clear [Bouchard et al., 1988; Vogler et al., 1995; Stunkard et al., 1990]. Humans are born with different degrees of genetic predisposition to obesity, but it is the interaction of this predisposition with several environmental factors that determines obesity. For example, the Pima Indians of Arizona were a group of lean and healthy people who were physically active and ate a healthy diet. As they adopted a more westernized lifestyle, they stopped farming and they increased their consumption of high fat foods and alcohol. As a result their bodyweight increased drastically. On the other hand, another group of Pima Indians who lived in Northern Mexico have maintained a healthy lifestyle by working on farms with no use of motorized equipment; and consuming a diet high in carbohydrates and low in fats. As the means and standard deviation figures in **figure 1** show, the Pima Indians of Arizona had increased weight (90.2 +/- 21.1 vs. 64.2 +/- 13.9 kg), BMI (33.4 +/- 7.5 vs. 24.9 +/- 4.0 kg/m2), and plasma cholesterol (174 +/- 31 vs. 146 +/- 30 mg/dl) compared to those living in Mexico [Ravussin et al., 1994].

Figure1. Weight (kg), BMI (kg/m^2), and Plasma cholesterol levels (mg/dl) of Pima Indians living in Arizona and Mexico.



Ravussin et al., 1994

.1.4.2. Nutrition

In general, an increase in weight occurs when energy intake exceeds energy output. However, evidence shows that even though total energy intake has decreased in the United States and Great Britain [Cavadini et al, 2000; Prentice et al, 1995], obesity rates have risen in both countries [Ebbeling et al, 2002]. This rise may be partly explained by a decrease in the consumption of nutritious meals and milk and an increase in the consumption of fast food meals and soft drinks [Cavadini et al, 2000]. Another equally important possibility is that the energy requirements of physical activity (PA) may have witnessed a greater decline than that of energy intake [Prentice et al, 1995].

.1.4.2.1. Fast Food Consumption

The increase in the consumption of fast food in many developed and westernized countries may be a strong contributor to the prevalence of obesity. Saturated fats, carbohydrates with a high glycemic index, low nutrition profile, and large portion size are all suited descriptions of fast food meals. Studies show a strong association between the frequency of visits to fast food restaurants and increases in body weight and insulin resistance [Pereira et al., 2005]. Fast food consumption is also strongly associated with weight gain and with the prevalence of obesity [Binkley et al., 2000]. Moreover, fast food consumption is also correlated with higher BMI levels, and the possibility of being obese increased as the frequency of fast food consumption increased [Schröder et al., 2007]. This is supported by another study which reported that energy intakes were higher on days where subjects consumed fast food than on non-fast food days [Bowman and Vinyard, 2004]. Most meals at typical fast food chains are characterized by their high fat and caloric content [Dumanovsky et al., 2009]. This has led to the suggestion that the high energy densities of fast foods challenge human appetite control systems with conditions for which they were never designed. This may lead to passive over-consumption [Prentice and Jebb, 2003].

Other nutritional factors such as breakfast consumption [Farshchi et al., 2005], portion size [McConahy et al., 2002], and dietary behavior [Newby et al., 2004] have also been suggested as contributors to the cause of obesity.

.1.4.3. Parental Influence

Excluding hereditary factors, a study reported that parental obesity more than doubles the risk of adult obesity among both obese and non-obese children less than 10 years of age [Whitaker et al., 1997]. Another study concluded that parents with unhealthy eating habits may foster the development of excess BF in their children [Hood et al., 2000]. In the same manner, parents who force their children to eat more may lead them to over consume and thus cause an increase in weight [Klesges et al., 1983]. Based on these findings, some studies have suggested that the treatment of childhood obesity should incorporate family based behavioral interventions [Wrotniak et al., 2004].

.1.4.4. Environmental Changes

In 1996, Battle and Brownell wrote, “it is hard to envision an environment more effective than ours [in the USA] for producing obesity” [Battle and Brownell, 1996]. This statement may be applicable to many parts of the world following the same westernized way of life. Along with the technological development, several environmental factors may contribute to the prevalence of obesity. Examples of these factors are; greater availability and affordability of food, limited access to adequate space (ex. parks, playgrounds, walking routes) for PA mostly as a result of urban sprawl, reduced occupational PA, and increased use of vehicles for transportation [Davey 2004; Kipke et al., 2007; Brownson et al., 2005].

.1.4.5. Sedentary Activity

Sedentary activity can be defined as an action in which physical inactivity is dominant, or in other words, the resulting energy expenditure is close to energy expenditure at rest which is less than or equal to 1.5 METs. One Metabolic Equivalent (MET) for the average adult is equivalent to 1kcal per kg of body weight per hour [Ainsworth et al., 1993 a].

Changes in lifestyle in addition to the lack of opportunities for being physically active may have led to an increase in sedentary activity through greater use of computers, televisions, and video games. In many studies, time spent watching television is the only form of sedentary activity studied. A self report study of 8 to 16 year olds found that those who watched television for more than four hours had the highest BMI and trunk skin fold measurement, whereas those who watched television for less than an hour had the lowest BMI [Anderson et al., 1998]. These findings are similar to those reported in other studies which measured television viewing combined with other sedentary activities such as playing videogames, reading books and/or using computers [Hanley et al., 2000; Crespo et al., 2001]. On the other hand, some studies found no relation between TV viewing time and obesity. In one self reported study of 6 and 7 grade girls, no relation was found between BMI, triceps skin fold, and TV viewing [Robinson et al., 1999]. Another study conducted in children reported similar findings [Durant et al., 1994].

Television viewing may lead to weight gain not only by limiting energy expenditure, but also by causing an increase in energy intake. In fact, one study reported that increased television viewing time may be associated with elevated consumption of high-fat and high-sugar foods resulting in increased daily energy intake [Manios et al., 2009; Utter et al., 2006]. This finding is supported by other studies that reported that US and British children are exposed to about ten food commercials per hour of television time, most focusing on fast food, soft drinks, and sweets [Kotz et al., 1994; Lewis and Hill, 1998, Batada et al., 2008]. It is now well established that, independent of PA, prolonged television viewing is a risk factor for obesity both in children [Gortmaker et al., 1996; Andersen et al., 1998] and adults [Hu et al., 2001 a; Hu et al., 2003]. For this reason, the most effective intervention programs to prevent obesity in children and adolescents have included recommendations to limit television viewing [Gortmaker et al., 1999; Robinson et al., 2003]

.1.4.6. Physical Activity

The relation between various PA parameters and the development of obesity has received great attention. However, as seen in the next section, methodological limitations in the assessment of PA pose a serious challenge for researchers.

.1.4.7. Summary

Obesity may be viewed as the consequence of a complex interaction between predisposition to obesity (genetics) and several environmental factors (lifestyle). This may result in a small but cumulative disruption in the homeostasis of the energy balance equation. An ever changing environment characterized by boundless food availability, and an increasingly sedentary lifestyle with less chances for PA creates the perfect milieu for obesity to thrive.

.1.5. Consequences of Obesity

It is well established that excess weight increases the risk of developing medical complications that affect nearly every major organ in the body. This relation is established through the association of BMI with morbidity. In fact, as presented in table 4, a study conducted by the Lewin group clearly demonstrates the direct correlation between increases in BMI and elevated risk of developing arthritis, type-2 diabetes, gallstone disease, hypertension and heart disease. Their findings are consistent with other studies which have shown that overweight (BMI≥ 25) and obesity (BMI≥ 30) are correlated with the prevalence of hypertension [Stamler et al., 1978; Despres et al., 1990], coronary heart disease [Hubert et al., 1983], diabetes [Golay and Ybarra, 2005], gallbladder disease [Diehl 1991], osteoarthritis [Felson et al., 1988], obstructive sleep apnea [Loube et al., 1994], and certain types of cancers [Garfinkel, 1985]. Some of these complications are discussed below.

Table4. Relative risk of morbidity with BMI status in adults.

Disease	BMI≤ 25	BMI >25 < 30	BMI ≥30 < 35	BMI ≥ 35
Arthritis	1.00	1.56	1.87	2.39
Heart disease	1.00	1.39	1.86	1.67
Diabetes (type- 2)	1.00	2.42	3.35	6.16
Gallstones	1.00	1.97	3.30	5.48
Hypertension	1.00	1.92	2.82	3.77
Stroke	1.00	1.53	1.59	1.75

Source: Centers for Disease Control. Third National Health and Nutrition Examination Survey, Analysis by the Lewin Group, 1999

.1.5.1. Hypertension

A person is considered hypertensive in the case of the presence of a mean systolic blood pressure of ≥140 mm Hg or a mean diastolic blood pressure ≥90 [Chobanian et al., 2003]. High blood pressure increases as BMI rises. In one study, the prevalence of high blood pressure and mean levels of systolic and diastolic blood pressure among adults under 60 years increased as BMI increased. In fact, at a BMI of greater than 30, 49.1% of men and 37.8% of women were diagnosed with hypertension compared to 14.9% and 15.2% respectively at a BMI of less than 25 [Brown et al., 2000]. In another study it was reported that a ten kilogram difference in bodyweight in adults is associated with higher systolic and diastolic blood pressure. Differences of 2-3 mmHg in systolic blood pressure on a population basis have been shown to be associated with differences in stroke mortality rates of 6-9 % and in coronary death rates of 4-6 % [Dyer and Elliot, 1989]. In adolescents, it has been shown that obese individuals have a much higher risk of developing hypertension as compared to non-obese individuals [Lauer et al., 1975]. In the same manner, overweight adolescents were 8.3 times more likely to develop hypertension during young adulthood [Srinivasan et al., 1996].

.1.5.2. Dyslipidemia

Dyslipidemia is characterized by an abnormal lipid profile in the blood, mainly a total cholesterol level over 240 mg/dL. It is often accompanied by hypertension. Increased bodyweight is associated with higher levels of cholesterol in both men [Denke et al., 1993] and women [Denke et al., 1994]. Being overweight as an adolescent is associated with a 2.4 fold increase in the prevalence of high cholesterol during young adulthood [Srinivasan et al., 1996]. Moreover, cholesterol levels are more elevated in individuals with increased abdominal obesity [Reeder et al., 1992] suggesting that the distribution of BF may also have an effect irrelevant of the quantity of BF. Other contributors to Dyslipidemia, such as elevated triglycerides [Denke et al., 1993; Denke et al., 1994] and lower high density lipoproteins [Glueck et al., 1980] have also been known to be associated with BMI levels. In adolescents, abnormal lipid profiles are more commonly found in obese boys [Lauer et al., 1988].

.1.5.3. Type 2 Diabetes

Non-insulin-dependant diabetes mellitus or type-2 diabetes originates as insulin resistance. It occurs when the cells cannot use insulin properly, as the need for insulin rises; the pancreas loses its ability to secrete it. Overweight and obesity are strong risk factors for the development of type 2 diabetes. A study using a self report questionnaire found that starting from a BMI as low as 22.0 kg/m^2, the risk of developing type 2 diabetes begins to rise [Colditz et al., 1990]. In the Nurses Health Study, compared to a BMI of less than 23 kg/m^2, it was reported that for a BMI between 30.0 and 34.9 kg/m^2, the relative risk of developing Type-2 diabetes was 20.1, and for a BMI greater than 35.0 kg/m^2 the relative risk was 38.8 [Hu et al., 2001 b]. In a follow up study from 1976 to 1990 among a large group of nurses who were free from diabetes at baseline, the relative risk for developing diabetes compared with those whose weight remained stable was 1.9. For those with a weight gain between 5.0 and 7.9 kilograms, 2.7 for a weight gain of 8.0 to 10.9 kilograms, and 12.3 for an increase of over 20.0 kg. On the other hand, those who lost more than 5.0 kilograms reduced their risk by at least 50% [Colditz et al., 1995]. Some studies have found that alternative measures of body weight such as waist circumference and waist to hip ratio are also highly correlated with type 2 diabetes, thus suggesting an independent role for central adiposity [Wang et al., 2005; Balkau et al., 2007]. Moreover, it was suggested that because of its additional effect on risk prediction, waist circumference should be measured in addition to BMI to assess the risk of type 2 diabetes in both men and women [Meisinger et al., 2006]. However, other studies have found that BMI, waist circumference, and waist to hip ratio have similar associations with diabetes. Thus further research is needed to determine the usefulness of waist circumference or waist to hip ratio over BMI [Vazquez et al., 2007].

Once common in adults only, the prevalence of type 2 diabetes among children and adolescents is also on the rise [Wabitsch et al., 2004; Weigand et al., 2004; Rosenbloom et al., 1999]. A study conducted among 10-19 year old subjects reported that 90.0% of those diagnosed with diabetes had a BMI above the 90th percentile, and that the prevalence of type-2 diabetes has increased ten-fold over the same period in which childhood obesity increased [Pinhas-Hamiel et al., 1996]. Elevated insulin secretion in overweight and obese children and adolescents has been significantly associated with morbidity during later adult life [Must et al., 1992; Mossberg 1989]. For example, one large study reported that 2.4% of overweight adolescents developed type-2 diabetes by the age of 30, while none of the adolescents in the lean group were diagnosed with type-2 diabetes at that stage [Srinivasan et al., 1996]. Early recognition of risk factors and prevalence of type-2 diabetes in pediatric populations may help prevent the disease from developing or even reverse its progression. In fact, it has been reported that loosing weight can help pre-diabetic subjects by preventing onset of diabetes and reducing blood glucose to normal levels [CDC 2005].

.1.5.4. Gallbladder Disease

Studies have shown that the risk of gallstone disease increases as weight increases, its prevalence being lower among men [Sun et al., 2009]. In women, for those with a BMI under 24 kg/m^2, the disease prevalence is 3.0 per 1000. Those with a BMI over 40, the prevalence increases to 20 per 1000 [Stampfer et al., 1992]. Obesity is a strong risk factor for the development of gallstones. This risk has been shown to increases even further in obese individuals after adopting a very low calorie diet [Everhart 1993].

Gallstone disease also occurs among children and adolescents. Studies suggest that the disease is rare among prepubertal children. However, it is highly prevalent among obese adolescents who were previously treated with dietary interventions [Kaechele et al., 2006]. Moreover, it may also occur among adolescents who undergo bariatric surgery [Fernstrom and Courcoulas, 2008].

.1.5.5. Osteoarthritis and Orthopedic Complications

Osteoarthritis occurs as a result of breakdown of cartilage in the joints, especially the knees, hips and lower back. Individuals who are overweight or obese are at an increased risk of developing osteoarthritis [Hochberg et al., 1995; Cicuttini et al., 1996].

The association between obesity and knee osteoarthritis is documented [Felson et al., 1997; Gelber et al., 1999]. However, the relation between obesity and hand osteoarthritis is still controversial [Woolf et al., 2006]. In one study it was concluded that the risk of developing osteoarthritis in the joints of the hands increases 9-13% for every one kilogram increase in bodyweight [Cicuttini et al., 1996]. On the other hand, studies in both sexes reported no significant association between obesity and hand osteoarthritis [Hochberg et al., 1991; Hochberg et al., 1993]. Unlike other diseases, it has been shown that osteoarthritis in the hands, feet, and knees is not associated with the pattern of BF distribution [Davis et al., 1990]

Studies have suggested that certain types of physical activities may result in large improvements in physical function and decrease pain associated with chronic knee and hip osteoarthritis [Fransen et al., 2007]. Another study suggested that minor weight reduction may be used as a preventive health measure for osteoarthritis [Cicuttini et al., 1996].

In children and adolescents, certain orthopedic complications have been associated with obesity. For example, in children, arching of the legs below the knee or Blount's disease has been reported in obese subjects. Although the condition is not common, 60-80% of children diagnosed with the disease are obese [Dietz et al., 1982]. In adolescents, a rare condition known as slipped capital femoral epiphysis has been reported to be more prevalent among the overweight. This could be possibly due to the increased downward force on the growth plate of the hips [Taylor et al., 2006].

.1.5.6. Metabolic Syndrome

This term is used to describe the co-prevalence of a combination of medical disorders and central obesity. More precisely, the condition involves the presence of cardiovascular risk factors such as obesity, hypertension, dyslipidemia, and insulin resistance [Liese et al., 1998]. Studies have shown that the metabolic syndrome strongly predicts future risk of cardiovascular diseases [Ford 2005; Dekker 2005;]. In 2005, the International Diabetes Federation redefined the metabolic syndrome as central obesity plus any two of the following conditions: hypertension, hypertriglyceridemia, reduced HDL cholesterol, or impaired fasting glucose [Alberti et al., 2005]. Table 5 presents the criteria for diagnosing the metabolic syndrome as recommended by the American Heart Association, the National Heart, Lung, and Blood Institute, and the International Diabetes Federation. The prevalence of the metabolic syndrome among adult populations worldwide is elevated [Ford et al., 2002; Magi et al., 2005; Gupta et al., 2004; Al-Lawati et al., 2003; Ozsahin et al., 2004]. Studies conducted in many countries have also reported a high prevalence of the metabolic syndrome among overweight and obese children and adolescents [Cook et al., 2003; Li et al., 2008; Cruz et al., 2004; Bokor et al., 2008]. These reports are very alarming especially since it has been shown that the components of the metabolic syndrome track from childhood to adulthood [Bao et al., 1997; Srinivasan et al., 2003], and thus the prevalence of the syndrome among adults is likely to increase dramatically in the future. Despite this, some studies have suggested that PA may have a positive effect on the problem. In fact, it has been reported that relatively small increases in PA may reduce the risk of the metabolic syndrome in healthy children [Ekelund et al., 2009]. In the same manner another study concluded that maintaining a physically active lifestyle across the lifespan may also prevent or delay the onset of metabolic syndrome in young male and female adults [Yang et al., 2008].

Table5. Definition of Metabolic Syndrome in children, adolescents, and adults

Age	Obesity (WC)	Triglycerides	HDL-C	Blood pressure	Glucose
6-<10*	≥90th percentile				
10-<16	≥90th percentile	≥150mg/dl	<40mg/dl	Systolic BP ≥130 or diastolic ≥85 BP mm Hg	FPG 100mg/dl or T2DM
16+	WC ≥ 94cm for Europid males and ≥ 80cm for Europid females, with ethnic-specific values for other groups	≥150mg/dl or specific treatment for high triglycerides	<40mg/dl in males and <50mg/dl in females, or specific treatment for low HDL	Systolic ≥130 or diastolic ≥85 mm Hg, treatment of previously diagnosed hypertension	FPG 100mg/dl or T2DM

BP: blood pressure; HDL-C: high-density lipoprotein cholesterol; FPG: fasting plasma glucose; T2DM: type 2 diabetes mellitus; WC: waist circumference.
Metabolic syndrome cannot be diagnosed, but further measurements should be made if there is a family history of metabolic syndrome, T2DM, dyslipidemia, cardiovascular disease, hypertension and/or obesity.
Diagnosing the metabolic syndrome requires the presence of central adiposity plus any two of the other four factors.

.1.5.7. Psychosocial Consequences

Research suggests that overweight and obesity may also have an effect on the psychological wellbeing of individuals. Studies show that since early childhood, children are more likely to express negative attitudes towards overweight peers [Hill et al., 1995] and regard overweight classmates as the least preferable friends [Strauss et al., 1985]. A study conducted among 8 to 13 year old children demonstrated that adiposity is associated with increased psychological suffering manifested by low self esteem, body image dissatisfaction, and eating disorder symptoms [Gibson et al., 2008]. Moreover, findings from a longitudinal study concluded that the perception of being overweight during adolescence, but not measured overweight, is a significant risk factor for depression in young adult men and women [Al Mamun et al., 2007].

.1.5.8. Health Related Quality of Life

The concept of Health-related quality of life (HRQOL) refers to an individual's subjective evaluation of his or her physical, social, and psychological health over time [Testa and Simonson, 1996].

It has been shown that in adults all domains of HRQOL are negatively affected by elevated BMI [Soltoft et al., 2009]. Other studies have reported that obesity is more associated with decreased physical health [Goins et al., 2003; Huang et al., 2006]. In children and adolescents, a review which analyzed data from thirteen studies using the Pediatric Quality of Life Questionnaire found that physical and social functioning scores consistently decrease as BMI increases [Tsiros et al., 2009]. Another study using a different questionnaire, reported that obese children have low scores for several health related quality of life domains and overweight children have significantly lower physical functioning scores than their normal weight peers [Friedlander et al., 2003].

.1.5.9. Summary

Research in the field of obesity is heavily driven by the impact that this condition has on the health and well being of individuals. Several studies have generated enough evidence to consistently state that obesity is a major contributor to the occurrence of many cardiovascular, metabolic, and orthopedic complications, with recent evidence suggesting that certain ethnicities are more vulnerable than others. The consequences of obesity are also depicted through its effect on the quality of life even without the presence of medical complications.

.1.6. Economic Cost of Obesity

The impact of obesity on society is multidimensional. In other words, it is not confined to the medical complications associated with such a condition. From a public perspective, obesity imposes a dramatic economic burden on society. For example, in 1995, the estimated cost of obesity in the United States was $99 billion dollars [Wolf and Colditz, 1998]. In 2000, the figure increased to $117 billion. These numbers were calculated as the sum of direct costs of medical care and indirect costs of lost productivity [U.S. Department of Health and Human Services 2001]. In Canada, the total direct health care cost in 1997 was estimated at over $1.8 billion [Birmingham et al., 1999]. In fact, it has been shown that obesity has an immense impact on the economies of numerous countries throughout the world [Thomson and Wolf, 2001; Zhao et al., 2008].

With the increase in the global prevalence of obesity, the ramifications of the problem are likely to grow and therefore place more pressure on the public and private sector to implement strategies aimed at reducing the economic effect of obesity.

2. Physical Activity and Energy Expenditure

PA represents the sole component of energy expenditure that can be altered by will. As a result, it has received great attention in various aspects of obesity research.

Obesity is a condition triggered by the interaction of genes with the environment. Put simply, it is caused by a recurring imbalance in the thermodynamic equation, with energy intake exceeding energy expenditure [WHO 1998]

.2.1. Definition of Physical Activity

The term physical activity has been used interchangeably with several other words such as exercise, fitness, physical education, etc. However the actual phrase has a clear definition. Physical activity is any bodily movement that is caused by skeletal muscle contraction and resulting in energy expenditure [Caspersen et al., 1985]. Therefore it incorporates all activities ranging from the slightest movement to the most strenuous exercise.

PA can be assessed based on either the quantification of the related energy expenditure of movement or on the characteristics (type, frequency, and intensity) of activity.

.2.2. Components of Total Energy Expenditure

Total energy expenditure can be separated into three components: Resting metabolic rate, thermic effect of food, and activity related energy expenditure [Hill 1994].

.2.2.1. Resting Metabolic Rate

The first component, resting metabolic rate, is the amount of energy needed by the body to maintain normal physiologic function at rest in a post-absorptive state. It may represent up to 70 % of the daily energy expenditure [Sharp et al., 1992]. Previously, it has been reported that energy expenditure of the resting metabolic rate is higher in obese children and adolescents as compared to normal weight youth [Epstein et al., 1989; Bandini et al., 1990 b]. This may be explained by the larger fat free mass of obese individuals. Recently, it was demonstrated that after adjustment for age, sex, and body composition, energy expenditure associated with resting metabolic rate did not differ between obese and normal weight children [Fontvieille et al., 1992].

.2.2.2. Thermic Effect of Food

The second component of total energy expenditure is the thermic effect of food. It involves the energetic cost of the digestion process. It may account for 10% of the total daily energy expenditure [Horton 1983]. Although not significant, some studies have suggested that the thermic effect of food may be slightly lower in obese children as compared to normal weight peers [Molnar et al., 1985].

The effect of macronutrient ingestion on the thermic effect of meals has been investigated thoroughly. Of the three macronutrients, proteins have the highest thermogenic effect and fats have the lowest [Nair et al., 1983]. Interestingly, some studies show that obese and post-obese individuals display an increased preference for dietary fat relative to lean controls [Drewnoski and Greenwood, 1983 ; Drewnoski et al., 1992]. Moreover, in a study that compared the effect of macronutrient ingestion on the thermic effect between obese and non-obese individuals. Results show that the thermic effect of carbohydrates and proteins was not different between obese and non-obese subjects. However, obese individuals show a reduced thermogenic response to fat [Swaminathan et al., 1985].

.2.2.3. Physical Activity Energy Expenditure

The last component of energy expenditure is related to PA. Depending on several factors [Livingstone et al., 1990] it may range between 15 and 50 % of total energy expenditure.

.2.3. Quantitative Aspect of Physical Activity

The total amount of PA energy expenditure is a result of the sum of the energetic cost of activities associated with daily living, planned exercise, and spontaneous activity such as fidgeting and shivering. Studies have shown that PA energy expenditure of obese children and adolescents is higher than non-obese subjects possibly due to their increased bodyweight and elevated fat free mass [Bandini et al., 1991 a; Maffeis et al., 1996; Treuth et al., 1998]. These findings provide a paradoxical suggestion in that PA energy expenditure is not correlated with obesity.

.2.4. Qualitative Aspect of Physical Activity

PA can be measured in terms of behavior without referring to its related energy expenditure. As such, the qualitative context of PA (type, intensity, duration, and frequency) can be measured and assessed.

The paradox of increased PA energy expenditure in obese subjects as compared to their non-obese counterparts may be further understood by using a qualitative approach. One study used objective criterion methods to measure both the qualitative and quantitative aspects of PA. The study reported that although PA energy expenditure was not significantly different between obese and normal weight adolescents, PA level was lower in the obese group [Ekelund et al., 2002]. Similar findings were reported in another study which concluded that PA energy expenditure in prepubertal children did not explain the variance in BF mass. However, a small proportion of the variance was explained by the time spent in recreational activities, as assessed by a questionnaire [Goran et al., 1997].

These findings suggest that PA cannot be viewed exclusively as equivalent to the energy cost of performing the activity, and therefore, the caloric expenditure of different forms of PA does not necessarily reflect the health benefits of these activities.

.2.5. Assessment of Physical Activity

Measuring PA faces many difficulties perhaps due to its complexity and multidimensional attributes. Current methods can assess PA in three ways, either as a behavior, or its resulting energetic cost, or both [Lamonte and Ainsworth, 2001]. The need for accuracy in measuring PA is necessary in order to evaluate interventions, determine trends, and perform comparisons between various populations [Wareham and Rennie, 1998]. However, the lack of an ideal standard makes the validation of new techniques even more challenging. Despite this, several methods have been developed. These include objective methods, such as direct calorimetry, indirect calorimetry, Doubly-labeled water (DLW), heart rate monitoring, accelerometry, and pedometry, and subjective methods such as questionnaires.

.2.5.1. Objective Methods

.2.5.1.1. Direct Calorimetry

This method dates back to the late 1800s. It measures body heat production directly through the use of a closed airtight chamber which is also known as a calorimeter [Webb 1991]. Besides being expensive, it cannot track rapid changes in energy release during exercise which makes it time consuming and burdensome. Therefore, this method is rarely used in research.

.2.5.1.2. Indirect Calorimetry

In this method, energy expenditure is calculated from the measurement of Oxygen uptake and carbon dioxide production using prediction equations [da Rocha et al., 2006]. Usually subjects are required to wear a mouthpiece which is connected to a system that measures gas exchange. This approach is somewhat burdensome. However, because of its high accuracy, it is widely used for the validation of other methods. Nevertheless, studies conducted in children show significant reliability for new portable versions of indirect calorimetry [Nieman et al., 2005].

.2.5.1.3. Doubly-Labeled Water

This method is considered the most precise and noninvasive way to measure total energy expenditure with high accuracy [Sirard and Pate, 2001]. It has been used widely in animals and humans including children and pregnant women. It was first applied to small animals by Lifson in the 1950s [Visser et al., 2000]. However, it was not until the 1980s that the method was applicable to humans [Schoeller 1988]. The technique involves the administration of specific isotopes orally or intravenously. Then, the difference in the rate of clearance of the isotopes from the body provides a measure of carbon dioxide production. From this, energy expenditure is calculated [Trabulsi and Schoeller, 2001]. This technique is useful for assessing energy expenditure in free living conditions, therefore minimizing the alterations that may occur in PA as a result of changing the natural environment, such as in a laboratory setting [Schoeller and Fjeld, 1991]. However, due to its high cost, technical complexity, and its inability to measure all dimensions of PA. It has been limited to the validation of other more simple methods of measuring PA energy expenditure.

.2.5.1.4. Heart Rate Monitors

Usually, a transmitter is placed on the chest and a device is worn on the belt or wrist. These devices are often used in research to provide estimates of energy expenditure of PA based on the relation between heart rate and oxygen consumption. However, assuming that this relation is universal can lead to less accuracy. In fact, a study conducted in adolescents demonstrated that failure to apply individual calibrations may lead to decreased accuracy in estimating energy expenditure [Ekelund et al., 2001]. Some have also suggested that the precision of heart rate monitors decreases in sedentary individuals because the relation between heart rate and oxygen consumption is much weaker during low-level PA [Saris 1986; Meijer et al., 1989]. Moreover, several factors such as fitness level [Kappagoda et al., 1979], environmental conditions [Sengupta et al., 1979], and emotional state [Brage et al., 2004] have also been known to influence heart rate. The use of heart rate monitors in combination with other methods has been shown to improve its accuracy in assessing PA [Strath et al., 2001; Strath et al., 2002].

.2.5.1.5. Accelerometry

This method is based on the use of a small portable device which has built in transducers (energy converter) and microprocessors to convert body accelerations into activity counts. It is the most commonly used method to assess PA in free living subjects. In fact, compared to other objective methods, its use has increased greatly across all age groups [Rowlands 2007]. Studies conducted in children [Freedson et al., 2005] and adults [Matthews 2005] have shown that movement counts recorded by accelerometers are strongly correlated with results obtained from other objective methods such as doubly labeled water and oxygen uptake. Accelerometers vary in accuracy and reliability. However, no single accelerometer can be considered for use over the others because till now, direct comparisons of different models are not abundant [Plasqui and Westerterp, 2007]. Although using accelerometers in field studies is well accepted, certain limitations exist. First, they cannot detect changes in running velocities [Brage et al., 2003] or changes in muscular resistance. Second, the cost of some advanced models may limit their use in large scale studies.

.2.5.1.6. Pedometry

Similar to accelerometry, this method involves the use of small devices known as pedometers. They may be worn at the ankle, wrist, or hip. Pedometers measure vertical vibrations and provide a record of total steps. They were designed initially to assess walking. However, the first models were inaccurate and unreliable [Gayle et al., 1977; Washburn et al., 1980]. Newer models have better accuracy [Schneider et al., 2004]. Being a cheaper alternative to accelerometers, they are more widely used in large scale assessment of PA. Furthermore, because pedometers count steps/day they provide the advantage of straightforward comparison of results between various populations. Despite this, their use has some significant limitations. First, their accuracy may decrease during low intensity activities [Kemper et al., 1977] and therefore their ability to assess subjects with low intensity PA may be less precise. Second, there is some concern that excess BF around the pelvic area in overweight adults may cause the pedometer to tilt and result in less accurate readings [Melanson et al., 2004; Shepherd et al., 1999], although another study reported that the placement of the pedometer on various locations on the waistband did not affect the accuracy of the device for counting steps [Swartz et al., 2003]. Third, pedometers are limited to providing information on walking. It was recently demonstrated that their ability to measure activities such as skipping, galloping, sliding, and hoping may not be accurate [Smith and Schroeder, 2008]. This is especially important since these movements are typical of children activities.

.2.5.2. Subjective Methods

These are usually self-report methods. They are practical and inexpensive which makes them useful for large scale studies.

.2.5.2.1. Physical Activity Questionnaires

PA questionnaires are classified into 4 categories: diary surveys, recall surveys, quantitative histories surveys, and general surveys [LaPorte et al., 1985]. Questionnaires are well suited for large epidemiological studies [Pereira et al., 1997]. They can provide information on the type, duration, frequency, and intensity of PA.

A variety of questionnaires exist, most are developed to estimate occupational PA [Ainsworth et al., 1993 b; Reis et al., 2005], leisure time PA [Lamb and Brodie, 1990; Richardson et al., 1994], or total PA [Sallis et al., 1985]. Several questionnaires have also been developed to assess PA across different populations and in different age groups such as children [Goran 1998] and elderly [Bonnefoy et al., 2001].

Questionnaires may provide estimates of energy expenditure through the use of various grading scales such as kcal, METs, points, and indexes. Among these, the MET score has been widely used to reflect the caloric expenditure and intensity of activity. A good example of this would be the questionnaire originally developed by Kriska et al [Kriska et al., 1990], which was then modified and used in other studies [Deheeger et al., 1997]. One MET is the metabolic equivalent of energy expended at rest. Therefore, using previously estimated values, the energy cost of each activity may be expressed as multiples of resting metabolic rate [Ainsworth et al., 1993 a].

Studies have shown varying correlations between questionnaires and different types of methods. However, questionnaires have received criticism for achieving low validity when assessed against other more objective methods in adults [Hertogh et al., 2008; Bonnefoy et al., 2001; Starling et al., 1999; Prince et al., 2008] and in pediatric populations [Adamo et al., 2009]. These findings may be explained by several factors. First, the lack of a gold standard to measure PA implies that all methods are prone to errors. Second, questionnaires reflect various dimensions of PA ranging from a few days up to a lifetime, whereas techniques such as the DLW measures energy expenditure of activities within a few days. These issues may cause objective methods to generally underestimate the validity of questionnaires to accurately assess PA [Neilson et al., 2008]. Despite this, questionnaires are still the most feasible and applicable method for assessing PA in large-scale studies across all populations.

.2.5.3. Summary

PA is a highly modifiable component of total energy expenditure that varies greatly between individuals. PA is a very broad term that may incorporate any movement resulting from skeletal muscle contraction. As such, it can be expressed using several features each of which may act independently on health. These include energy expenditure, intensity, duration, frequency, and type. Accurate assessment of these features is necessary for obesity related research.

Although, the lack of a gold standard against which to assess other methods is problematic. Nevertheless, as depicted in table4, available techniques include: objective methods such as doubly labeled water, accelerometers, and heart rate monitors and subjective methods such as questionnaires. Each of these methods has certain advantages and weaknesses. Objective methods are highly accurate. However, they may not be feasible in large scale studies. Among the subjective methods, recalls are reasonably accurate, but they may require significant commitment from participants. Thus, other types of questionnaires are recommended for assessing PA in large scale studies.

Table4. Characteristics of physical activity assessment methods

Method	Description	Advantage	Disadvantage
Direct calorimetry	Directly measures body heat production using specialized chamber	Accurate	Limited availability, cannot track rapid changes in energy release during exercise
Indirect calorimetry	Measures oxygen uptake and Carbon Dioxide production to estimate energy expenditure	Accurate, portable	High cost, requires high participant cooperation
Doubly-labeled water	Measure energy expenditure from Carbon Dioxide production through the use of isotopes	Precise, noninvasive, used in free-living conditions, considered as the “gold standard”	expensive, cannot measure qualitative aspects of PA
Heart rate monitor	Measures heart rate (beats/minute) to provide estimates of energy expenditure	Minute by minute monitoring of heart rate during exercise	Limited to aerobic activities, may increase despite no physical movement
Accelerometry	Measures movement counts	Objective measure, easy to collect data, extended monitoring periods	May not capture all types of movements, high cost
Pedometry	Measures steps	Inexpensive, noninvasive, may alter behavior	Reduced accuracy when jogging or running
Questionnaire	Provides qualitative and quantitative data	inexpensive, suitable for large scale studies	Difficulty with recall of activity, possibility for bias

.2.6. Physical Activity and Health

As the prevalence of overweight and obesity continues to rise worldwide, health related complications are expected to concurrently increase as well. Given the numerous health benefits of PA and the detriments of being inactive, the need to increase PA has been stressed thoroughly.

Research consistently links PA to numerous health improvements. Several studies which evaluated the association between PA and BMI with the risk of cardiovascular disease have reported that PA is significantly associated with cardiovascular diseases even after controlling for obesity [Lee et al., 1999; Stevens et al., 2002]. Indeed, increased PA has been shown to predict lower risk of cardiovascular disease independent of obesity [Blair et al., 1998]. It has also been suggested that PA plays a role in managing and reducing the risk of developing hypertension [Basset et al., 2002].

PA may also decrease insulin resistance and play a role in the prevention and management of type 2 diabetes [Knowler et al., 2002; Tuomilehto et al., 2001]. In fact studies have reported an inverse relationship between PA and insulin resistance which is known to cause type 2 diabetes [Eriksson and Lingarde, 1996; Helmrich et al., 1991].

PA has also shown benefits in obese subject who are considerably active. A number of studies reported that PA lowers the risk of being overweight and obese, and overweight or obese subjects with a high PA level have a lower mortality rate when compared to normal weight sedentary subjects [Blair and Brodney, 1999; Hu et al., 2001 a; Hu et al., 2001 c].

Another way in which PA affects health can be observed through the impact of weight loss on HRQOL. In a study conducted on 141 women and 20 men with an average BMI of 41.1 kg/m^2 and an average age of 44.9 years, researchers assessed the effect of a one year outpatient weight reduction program. They concluded that physical function and self esteem were significantly affected by weight loss [Kolotkin et al., 2001]. This is consistent with another study conducted on 212,000 respondents which reported that among people with arthritis, a condition related to obesity, recommended levels of PA were associated with fewer mean physically and mentally unhealthy days and a decreased probability of having severely impaired physical or mental HRQOL [Abell et al., 2005].

.2.7. Patterns and Trends in Physical Activity

Research dealing with PA is challenged by the lack of instruments that can accurately measure all aspects of PA. The matter is further complicated by the methodological differences that are present between studies [Armstrong and Welsman, 2006]. Nevertheless, after reviewing the available literature on the patterns and trends in physical activities, several conclusions can be drawn.

In general, results from the Youth Risk Behavior Surveillance System in the United States report higher PA levels in boys than girls [Kann et al., 1998], similarly, another study suggested that European boys are more active than girls especially when vigorous PA is considered [Armstrong and Welsman, 2006]. These findings are also supported by data showing that even among 5 to 6 year old children, boys are more active than girls [Gutin et al., 1990]. In contrast, a study from china, reported that among adolescents, more females than males participate in school sports activities [Tudor-Locke et al., 2007].

PA tends to decline from childhood to adolescence [Kann et al., 1998]. This is supported by two other studies. The first study, conducted on data from 32 countries, reported that older children are significantly less active than younger children [Borracinno et al., 2009]. The second study reported that PA decreases before high school and tends to drop through the high school grade levels [Sallis 1993]. Children are also more active in the winter than in the summer and on weekends compared to weekdays [Sallis et al., 1992]. Interestingly, another study reported that obese children are less active on weekends than during the week [Aires et al., 2007]. In a recent review which included 41 studies that met the inclusion criteria, researchers concluded that total PA among children and adolescents seems to be decreasing over time and activity levels in physical education classes are also decreasing [Knuth and Hallal, 2009].

.2.8. Social Influence on Physical Activity

Studies show that among adolescents, confidence to perform exercise is a strong predictor of future PA pattern [Reynolds et al., 1990]. Moreover, it has been suggested that social support (parents and friends) for PA significantly affects adolescents' perceptions of and engagement in PA [King et al., 2008]. This is consistent with another study which concluded that during early adolescence, the participation of girls in sports is particularly affected by the social influence of peers (e.g. friends, classmates, boyfriends) [Keresztes et al., 2008]. In another study conducted in 3352 10-18 year olds several findings were reported. First, children with high socioeconomic status were more involved in sports. Second, girls show a greater tendency to participate in sports activities when their mothers participated. Third, the influence of a physical education teacher had no effect on the level of participation in sports activities [Seabra et al., 2008]. These findings should be taken into account when designing an intervention program.

3. Synopsis

Obesity is a pathological condition characterized by excess adiposity. Several methods have been developed for the assessment of body composition, with each having certain strengths and weaknesses. Among these, the BMI is a widely used tool for assessing obesity in large scale studies. Using this simple method, research reported high prevalence for obesity among children and adults worldwide.

In general, obesity is caused by small but cumulative disruptions in the energy balance equation. An evolving environment characterized by boundless food availability, and an increasingly sedentary lifestyle coupled with less chances for PA creates the perfect milieu for obesity. Because of this, the relation between nutrition, PA, and body composition has received great attention in obesity-related studies.

Although the association is not yet fully understood, studies show a consistent relation between reduced PA and increased prevalence of obesity. Since PA is a highly modifiable and variable component of total energy expenditure. It may be viewed as a potential cause of weight gain.

If success in the field of obesity is driven by the need for prevention and management, then, improving the assessment of body composition and PA may lead to a deeper comprehension of this relation.

PERSONAL CONTRIBUTION

Thesis Objective and Aims

There is consistent evidence that obesity is associated with serious health complications. There can be little doubt that the global increase in childhood and adolescent obesity will have major public health implications for many countries. Obesity related research in Lebanon is not yet viewed with the attention it deserves. Despite this, BMI-based results show that obesity among adolescents is comparable to many other countries. A physically inactive lifestyle is a risk factor for weight gain. Previous studies show that the prevalence of overweight and obesity is lower in girls. An understanding of these factors is essential for setting future policies and interventions.

The studies included in this thesis were guided by specific aims derived from the available literature. The following aims were investigated in the course of this study.

Specific Aim One

Assess the prevalence of overweight and obesity and examine their relation with physical activity, inactivity and quality of life among school-based Lebanese adolescents.

Specific Aim Two

Determine the relation between BMI and body fat in Lebanese adolescent girls.

Specific Aim Three

Asses the effect of physical activity level on the relation between BMI and body fat among Lebanese adolescent girls.

GENERAL METHODOLOGY

The procedures implemented in this study received approval from the institutional ethics committees of the University of Balamand and the University of Rennes 2.

1. Research Design

The project was conducted over a period of four months starting from March till June of the year 2005. The research design is cross-sectional in nature. It is divided into two phases. Data from phase one was used in study 1, and data from phase two was used in studies 2 and 3. The total number of subjects included in the three studies was 1047 participants.

1.1. Phase 1

The project director contacted the schools by telephone and scheduled appointments after obtaining verbal approval from each school administrator. Nine out of eleven schools agreed to take part in the study (National Orthodox School of Akkar, National Orthodox School of Mina, Lycee Jamhour, Lady of Balamand School, Lycee Verdun, Ecole des Apotres Junieh, Haret Sakher Public School, Rahbe Public School, and Kousba Public School). Six of these schools were private and three were public. Each school was visited during a physical education session. The questionnaire was administered to Grades 9 through 12. After a brief explanation of the study, the students provided verbal approval to participate. Then the questionnaires were distributed and the completion process commenced as the investigators aided the students and answered all their inquiries. The students were allowed to complete the questionnaires at home. Out of 1500 distributed questionnaires, 1000 were recollected on second visits.

1.1.1. Phase 1: Subjects

1000 subjects participated in completing the questionnaire. After a detailed examination, eighteen questionnaires were excluded because some subjects were older than 18 years of age and some questionnaires were incomplete. As a result, questionnaires from 422 boys and 560 girls between the ages of 14 and 18 were included.

1.1.2. Phase 1: Instruments

The distributed file was made up of four questionnaires. These are explained below

1.1.2.1. General questionnaire

In this two part section, subjects report information on age, sex, weight and height, in addition to some questions on TV viewing, computer use, and videogames (Appendix A)

1.1.2.2. Physical activity questionnaire

A validated two page questionnaire in children and adolescents [Deheeger 1997] was used as a measure of PA in the study subjects. It is a self-report recall questionnaire that may be completed in about 10 minutes. It can provide details regarding type, duration, and intensity of PA.

Subjects were asked to report information concerning PA across four domains: School, club, house, and leisure time (Appendix B). Results were presented as multiples of the resting metabolic rate where 1 MET is the amount of energy expended at rest or in other words, 1 MET is equivalent to 1Kcal/kg/hour. Using previously determined Metabolic Equivalent (MET) values [Ainsworth et al., 1993], a MET score was calculated for each reported activity using the following calculation: (Sessions per week) x (duration of each session) x (relative MET value) = MET score. Then the result of the MET scores of school, club, house, and leisure time were added as the total PA level per week.

1.1.2.3. Pediatric Quality of life Questionnaire

The Pediatric Quality of Life Questionnaire (PedsQL 4.0) French version [Varni et al., 1999; Varni et al., 2003] was used to evaluate the health related quality of life of the study subjects. This questionnaire has been validated, with internal consistency reliability >0.7. It can be completed in less than 5 minutes. It is made up of a total of 24 questions divided across four domains: physical (nine items), emotional (five items), social (five items), and school functioning (five items). The number of questions in each domain is divided by the total score in each domain and then multiplied by 100. For example, if a participant scores a sum of 18 on the physical domain, then his score is: (9 ÷ 18) * 100 = 50.

The total score is then calculated as the average of all four components of the questionnaire. Scores range from 0 to 100, with higher scores representing a better quality of life. (Appendix C)

1.2. Phase 2

In this phase of the project, subjects were recruited by personal contact. The objective and procedures of the study were explained thoroughly before approval to take part was obtained. Body weight and height were measured by standard anthropometric procedures and DXA whole body scans were performed. Additionally, a PA questionnaire was also completed. Participation was voluntary and subjects were free to withdraw at any time.

1.2.1. Phase 2: Subjects

The participants in phase 2 were healthy Lebanese females aged between 12 and 18 years. Recruitment was performed based on age and sex specific BMI cut-off values [Cole et al., 2000]. The initial aim was to create three BMI groups with 20 subjects in each group. However, subject recruitment was challenging especially for obese girls. Despite this, in study 2, fifty-one subjects were recruited. In study 3, the subjects increased to sixty-five participants (see below).

The following inclusion criteria was established to identify subjects for this study

- Self identify as Lebanese Female
- 12 to 18 years of age at the time of participation
- Self-report as at least twelve months past first menstruation
- No significant health disorder
- No use of medication
- Attend Physical Education classes regularly
- Not on any kind of nutritional diet

1.2.1.1. Phase 2: Study 2

51 adolescent girls participated in this study. BMI sorting was based on the cutoff points provided by Cole et al. Subjects were classified as follows.

Normal weight	Overweight	Obese
16	24	11

1.2.1.2. Phase 2: Study 3

Total number of participating subjects was increased to 65 adolescent girls. BMI sorting was based on the cutoff points provided by Cole et al. Subjects were classified as follows.

Normal weight	Overweight	Obese
21	25	19

1.2.2. Phase 2: Instruments

1.2.2.1. Anthropometric assessment

In studies 2 and 3, height and weight were assessed using the same instruments. Subjects were required to remove shoes and heavy outer clothing before commencing measurement. Bodyweight was measured on a Taurus mechanic scale with a precision of 140kg/100g. Height was measured to the nearest 1mm with a Seca stadiometer (model 222). BMI was calculated as Weight $_{kg}$/height $_{m}^{2}$.

1.2.2.2. Dual Energy X-ray Absorptiometry measurements

In studies 2 and 3, body composition was measured by dual-energy absorptiometry DXA (DXA Hologic QDR-4500W; Waltham, MA, USA). This method has been previously validated in obese and non-obese children and adolescents [Gutin et al., 1996; Thomas et al., 2005; Goran 1998]. Testing took place in a hospital setting by an accredited technician which performed the same procedure for all measurements. The in vivo coefficients of variation were 1.13 and 0.54% for fat and FFM, respectively. The DXA measurements were completed using the instrument previously described. BF mass and FFM were determined. %BF was then calculated as the ratio of fat mass to weight multiplied by 100.

1.2.2.3. Physical activity questionnaire

In study 3, subjects were required to complete a physical activity questionnaire (see section 1.1.2.2)

2. Data transfer

The data collected from the questionnaires, anthropometric measures, and whole body DXA scans were recorded in a Microsoft Excel computer spreadsheet using identification codes. DXA results were shared with the participant after they became available.

3. Data analysis

Two researchers were in charge of data input and analysis. The study sample was described using measures of central tendency (means) and variability (standard deviation). Descriptive data included age, height, weight, BMI scores, PA and inactivity variables, quality of life scores, and whole body DXA scans (BF, %BF, and FFM). Comparisons were performed using one way analysis of variance (ANOVA). Linear regression analysis was used to assess the relation between variables.

Data was analyzed using SIGMA STAT 1.0 (Jandel Scientific, San Jose, CA, USA) and NCSS 2001 (NCSS LLC, Kaysville, UT, USA). A value of $p<0.05$ was accepted as the minimal level of statistical significance.

<u>RESEARCH STUDIES</u>

III. RESEARCH OUTPUTS

Listed below are the peer-reviewed publications that have resulted from this thesis, in addition to the publications currently under review. The published versions of all papers are presented in the Appendix section

Peer-Reviewed Publications

Fazah A, Jacob C, Moussa E, El-Hage R, Youssef H, Delamarche P. Activity, Inactivity and Quality of Life Among Lebanese Adolescents. ***Pediatr Int***. 2009 Dec 17. [Epub ahead of print]. Appendix E

Fazah A, Jacob C, El-Hage R, Delamarche P, Moussa E. Body Mass Index and Body Fat in Lebanese Female Adolescents. ***J Med Liban***. [2010; 58(2):97-100]. Appendix F

Fazah A, El-Hage R, Jacob C, Greige H, Delamarche P, Moussa E. Taking Physical Activity level into Account Improves Body Fat Estimation in Adolescents. ***Science and Sports*** [accepted]. Appendix G

Study 1: Activity, Inactivity and Quality of Life among Lebanese Adolescents

INTRODUCTION

During the past decades, studies have found an unprecedented rise in the prevalence of overweight and obesity among children and adolescents in many parts of the world [Kosti et al., 2006; WHO, 2000]. Obesity is caused primarily by a disruption in the delicate homeostasis between energy intake and energy expenditure. Consequently, any parameter that may upset this balance may be considered a risk factor for the development of obesity. PA and inactivity are factors that may influence the prevalence of obesity [Tsiros et al., 2008; Ischander et al., 2007; Ponjee et al., 1996; Ivy, 1997; Raitakari., 1997] especially because they are modifiable.

Numerous studies concerned with young populations have been using the Pediatric Quality of Life Inventory (PedsQL) to assess the HRQOL in children and adolescents. Some studies have shown that obesity is associated with low HRQOL scores among children and adolescents [Schwimmer et al., 2003; Varni et al., 1999; Williams et al., 2005].

Evidence suggests that obesity in the Middle East is following the same trend as in Western countries [Bener et al., 2006; Al-Isa, 2004; Sibai et al., 2003 a]. To our knowledge, however, there is no existing literature on PA, inactivity, and HRQOL among adolescents in the Middle East.

OBJECTIVE

The aim of the present study is to assess PA, Screen time (sum of time spent in front of TV, computer, and Videogame), and HRQOL among normal, overweight, and obese adolescents in Lebanon.

SUBJECTS and METHODS

982 subjects took part in this study (Refer to phase 1 of the General Methodology).

Statistical analysis

Data are expressed as mean ± SD. Relations between BMI, and variables of PA, inactivity, and PedsQL in boys and girls were analyzed using Kruskal–Wallis one-way analysis of variance on ranks; in the event of significance, all pairwise multiple comparison procedures (Dunn's method) was performed. All statistical analysis was completed using SIGMA STAT (Jandal Scientific, San Jose, CA, USA). $P < 0.05$ was accepted as the minimal level of statistical significance.

RESULTS

Some questionnaires were not included in the study due to incomplete data. Subjects older than 18 years of age and those with chronic physical disabilities were exempted from participation. In all, a total of 18 subjects were excluded from the analysis. The final sample included 982 adolescents, with boys representing 42.9%.

Based on international age- and sex-specific cut-off points [Cole et al., 2000] the present results show that among Lebanese adolescents, 7.8% of boys and 1.75% of girls are obese, and 22.5% of boys and 12.47% of girls are overweight.

Table 1 lists the PA scores of the boys and girls who were assessed in the present study. In boys, scores for PA at health clubs were higher in the normal-weight group compared to the obese group. In contrast, in girls, leisure time PA and total PA scores were significantly lower in the obese group as compared to the normal-weight and overweight group. There was also a trend for lower levels of PA at school ($P = 0.063$) and at health clubs ($P = 0.067$) in the obese group. The results also show a significant gender difference in that boys reported significantly higher total PA scores than girls for the normal-weight, overweight and obese groups ($P = 0.0001$, $P = 0.004$, and $P = 0.0024$, respectively).

Table1. Physical activity variables per week (MET) vs. BMI grouping (mean ± SD)

	Boys				Girls			
	Normal n=283	Overweight n=95	Obese n=44	*P*	Normal n=480	Overweight n=70	Obese n=10	*P*
School	7.17 ± 8.7	5.54 ± 4.0	5.78 ± 2.3	0.196	5.45 ± 3.5	4.85 ± 2.6	3.70 ± 3.0	0.063
Health club	16.33 ± 31.9	10.47 ± 22.8	8.73 ± 24.4	0.027†	4.39 ± 12.3	1.46 ± 4.8	0	0.067
House	24.00 ± 29.7	25.84 ± 41.5	22.96 ± 24.0	0.719	21.12 ± 29.0	24.79 ± 30.8	14.23 ± 19.5	0.468
Leisure	80.1 ± 85.6	82.16 ± 72.0	46.42 ± 40.2	0.051	56.29 ± 59.8	46.85 ± 51.2	11.45 ± 8.3	0.001†
Total PA	126.58 ± 108.9	122.65 ± 99.8	82.11 ± 51.5	0.097	86.49 ± 72.9	77.54 ± 62.7	29.38 ± 26.9	0.0049†

†Statistically significant difference.
BMI, body mass index; MET, metabolic equivalent; PA, physical activity.

Screen time variables are shown in Table 2. Results yielded no significant group differences. Boys in the normal-weight group, however, had significantly higher total screen time than girls in the same group ($P = 0.004$); this gender difference was not seen across the overweight or obese group.

Table2. Screen time variables (h) vs. BMI grouping (mean ± SD)

	Boys				Girls			
	Normal	Overweight	Obese	*P*	Normal	Overweight	Obese	*P*
TV/wkdy	2.53 ± 1.4	2.77 ± 1.4	2.54 ± 1.2	0.254	2.71 ± 1.4	2.84 ± 1.2	2.65 ± 1.5	0.579
TV/wknd	4.85 ± 2.7	5.1 ± 2.6	5.78 ± 3.1	0.183	5.60 ± 2.8	6.22 ± 2.8	6.45 ± 3.2	0.112
Computer/ wkdy	1.20 ± 1.1	1.17 ± 1.1	1.40 ± 1.0	0.362	0.8 ± 1.0	0.63 ± 0.7	0.25 ± 0.4	0.084
Computer/ wknd	3.35 ± 2.4	3.23 ± 2.3	3.85 ± 2.8	0.388	2.08 ± 1.9	1.61 ± 1.5	1.6 ± 0.9	0.122
Videogame/ wkdy	0.41 ± 0.8	0.26 ± 0.5	0.38 ± 0.7	0.357	0.18 ± 0.5	0.22 ± 0.5	0.3 ± 0.6	0.691
Videogame/ wknd	1.31 ± 1.9	1.04 ± 1.5	1.10 ± 1.7	0.529	0.66 ± 1.3	0.73 ± 1.3	0.8 ± 1.2	0.701
Total screen time	29.3 ± 13.6	30.4 ± 13.2	33.0 ± 15.2	0.448	26.5 ± 13.5	26.9 ± 10.9	29.6 ± 10.8	0.45

Total screen time: (TV/school day) × 5 + (TV/weekend) + (computer/school day) × 5 + (computer/weekend) + (video game/school day) × 5 + (video game/weekend).
BMI, body mass index.

HRQOL variables are presented in Table 3. In boys, the normal-weight group reported a significantly higher physical functioning score than the obese group. In girls, the normal-weight group reported significantly higher physical functioning and average HRQOL scores as compared to the overweight group, and significantly higher social functioning scores as compared to the obese group. Results also show a significant gender difference (*P* = 0.001), in that boys reported higher average HRQOL scores than girls in both the normal and overweight group, this difference was not found in the obese groups.

Table3. Health-related quality of life* vs. BMI grouping

	Boys				Girls			
	Normal	Overweight	Obese	*P*	Normal	Overweight	Obese	*P*
Physical	84.8 ± 12.7	82.6 ± 13.4	77.1 ± 14.0	0.006†	78.7 ± 13.8	72.3 ± 14.1	76.5 ± 6.5	0.002†
Emotion	69.2 ± 16.0	68.0 ± 16.0	68.5 ± 18.2	0.675	58.8 ± 16.6	53.2 ± 15.7	56 ± 22.3	0.052
Social	85.4 ± 15.5	83.7 ± 15.1	83.3 ± 12.1	0.191	85.4 ± 14.3	80.7 ± 16.5	72.0 ± 6.7	0.0006†
School	76.6 ± 17.4	77.0 ± 15.1	73.3 ± 19.6	0.767	76.4 ± 16.0	74.4 ± 17.3	74.0 ± 10.2	0.518
Average	79.0 ± 11.2	77.8 ± 10.3	75.6 ± 13.1	0.361	74.8 ± 11.0	70.2 ± 10.8	69.6 ± 9.5	0.005†

* Higher scores indicate a better quality of life.
†Statistically significant difference. BMI, body mass index

DISCUSSION

To our knowledge this is the first attempt to assess the prevalence of obesity, PA, inactivity, and quality of life, among a population of 982 Lebanese adolescents aged 14–18.

Prevalence of overweight and obesity

The present results show that overweight and obesity among Lebanese adolescents is greater in boys than in girls. We used internationally accepted BMI cut-off points [Cole et al., 2000] and found that 7.8% of boys and 1.75% of girls are obese, and 22.5% of boys and 12.47% of girls are overweight. A previous study using the National Health and Examination Survey cutoff points found that 7.7% of boys and 2.9% of girls were obese and 29.9% of boys and 14.7% of girls were overweight [Sibai et al., 2003]. Moreover, another recent study using International Obesity Task Force cutoff points found that 10.1% of boys and 4.2% of girls are obese, and 28.8% of boys and 19.0% of girls are overweight [Chakar et al., 2006]. Since none of the BMI cutoff points have been validated against a direct measure of adiposity in Lebanon, there is a need to define new BMI cut-off points that are specific to the populations of the Middle East.

Obesity prevalence among Lebanese adolescents is lower than that of the USA and England [Baskin et al 2005; The Health and Social Care Information Centre, London 2004] but close to those reported in 11–16-year-old Canadian youth, for whom prevalence rates were greater in boys than in girls [Picket et al., 2004] With respect to other Mediterranean countries, the present results are comparable to those reported in studies using a similar definition for overweight and obesity. Prevalence rates were very similar to those found in Spain [Serra-Majem et al., 2006] and slightly higher than those reported in Greece [Kosti et al., 2007].

In the Middle East we found that the prevalence of overweight and obesity among Lebanese boys is much higher than those reported among Turkish boys. In contrast, Lebanese girls have a slightly higher prevalence of overweight and a similar prevalence of obesity compared to Turkish girls [Oner et al., 2007] Compared to other Arabian countries, overweight and obesity prevalence is still much lower than that found in Qatar [Bener, 2006] Bahrain [Al-Sendi et al., 2003] and Saudi Arabia [Al-Almaie, 2005].

Physical activity

The present results show a significant gender difference across all groups, in that boys reported higher PA levels than girls. This is in accordance with other studies [Eck et al., 1992; Gazzaniga and Burns., 1993; McMurray et al., 1995]

The findings show that obese girls have significantly lower leisure time and total PA scores than the normal-weight and overweight groups. This may be partially due to the lack of access to public parks and safe playgrounds, which has been known to negatively affect PA among adolescents [Cohen et al., 2006; Pate et al., 2008]. Moreover, obese girls also reported suppressed social HRQOL functioning scores. This may explain why they shy away from participating in sports activities or even any type of group physical activity. This may well be the reason why obese girls reported no use of gyms or health clubs at all.

Further research is needed to determine if excess bodyweight is reducing the desire and/or interest for physical activity or whether decreased levels of physical activity is the cause of increases in bodyweight. It is in the public health interest to establish physical activity guidelines and provide opportunities for the adolescent community, especially those with excess weight, to increase their levels of physical activity.

Physical Inactivity

Even though some studies show that television viewing, computer use and videogame playing may disrupt the body’s energy balance in many ways [Epstein et al., 2005; Matheson et al., 2004] the present results indicated no significant group differences in screen time variables in boys or in girls. One possible reason may be due to the fact that we assessed only screen time, and subjects might engage in other sedentary activities such as reading, playing cards or listening to music.

Compared with other studies, obese adolescents reported 19.11 ± 8.5 h per week of television viewing whereas US adolescents reported on average 21 h per week [Nielsen Media Research 1998]. Moreover, weekly total screen time reported by obese boys (33.0 ± 15.2 h) and girls (29.6 ± 10.8 h) was higher when compared to that reported among US boys (15.9 ± 0.53 h) and girls (20.3 ± 1.19 h), respectively [Boone et al., 2007]

Health-Related Quality of Life

Poor HRQOL was more pronounced in girls. Indeed, overweight girls reported lower physical functioning and average HRQOL scores than normal-weight girls, and obese girls reported lower social functioning score than normal-weight girls. This may be partially explained with findings from other studies that found that obese adolescent girls have fewer friends [Strauss and Pollack, 2003].

The boys in the normal-weight and overweight group reported higher average HRQOL scores than the girls. This difference was not seen in the obese group. Gender differences in HRQOL seem to disappear as obesity sets in. Thus, obesity among adolescents in Lebanon has similar implications for HRQOL among both boys and girls.

CONCLUSION

Despite certain limitations, the present study is the first to provide data on PA, inactivity, and HRQOL among Lebanese adolescents. Although there is a need for further research, all those concerned with the pediatric population are urged to develop and implement effective strategies to increase physical activity and improve HRQOL among adolescents based on the present findings.

Study 2: Body Mass Index and Body Fat in Lebanese Female Adolescents

INTRODUCTION

The prevalence of overweight and obesity has increased in many parts of the world [Kuczmarski et al., 1994; James, 1992]. An even more shocking phenomenon is the global rise among children and adolescents [Kosti and Panagiotakos, 2006]. The association of obesity with numerous health disorders has amplified the need for accurate assessment techniques of BF. However, these methods are usually complicated, expensive and time consuming, therefore making them inappropriate for population based studies. Therefore, other methods are used to estimate adiposity, among these the most widely used is the BMI. Even though it is a measure of excess weight rather than excess BF, studies have shown a high correlation between BMI and BF [Haslam and James, 2005; Goulding et al., 1996; WHO 2000]. By using appropriate cut-off points, BMI may be used to assess overweight and obesity. Although not as common, some studies have assessed obesity based on BF. These studies suggest a %BF of at least 25% of total body mass for men and 30-33% for women [Wellens et al., 1996; Frankenfield et al., 2001].

Despite the fact that age and sex specific BMI cut-off points have been developed and validated against direct measures of adiposity [Cole et al., 2000], defining overweight and obesity in children is complicated by the fact that weight varies with height as children grow.

Moreover, it has been suggested that the relationship between BMI and BF is affected by factors such as ethnicity and body build [Rush et al., 2004; Deurenberg and Deurenberg-Yap, 2001; Chang et al., 2003; Deurenberg-Yap et al., 2000]. Indeed, these studies have found that universal cut-off points may not be used to accurately assess overweight and obesity in certain Asian populations and therefore they recommend the use of lower BMI cut-off points to define obesity.

OBJECTIVE

In Lebanon and the Middle East, universal BMI cut-off points have been used to assess obesity [Sibai et al., 2003 a]. However, the relation between BMI and BF has never been assessed. Thus the aim of this study is to determine the relation between BMI and BF among Lebanese female adolescents.

SUBJECTS and METHODS

Fifty one adolescent females aged 12 to 18 years took part in the study. Bodyweight and height were measured using standard anthropometric methods. BF was assessed by DXA (refer to phase 2 of the General Methodology)

Statistical analysis

The means and standard deviations were calculated for all clinical data (table 1). Linear regression analysis models were used to test the relationship between fat mass % and BMI, as well as fat mass with BMI and r^2 coefficients were reported. Data was analyzed with NCSS (2001). A level of significance of $p < 0.05$ was used.

RESULTS

Descriptive information of the subjects is found in table 2. The participants were classified according to the age and gender specific BMI cut-off points shown in table 1 [Cole et al., 2000] as follows, 16 normal weight, 24 overweight, and 11 obese.

Table1. Age and sex specific BMI cutoff points (Cole et al., 2000)

Age	Overweight	Obese
12	21.68	26.67
13	22.58	27.76
14	23.34	28.57
15	23.94	29.11
16	24.37	29.43
17	24.7	29.69
18	25	30

Cole et al., 2000

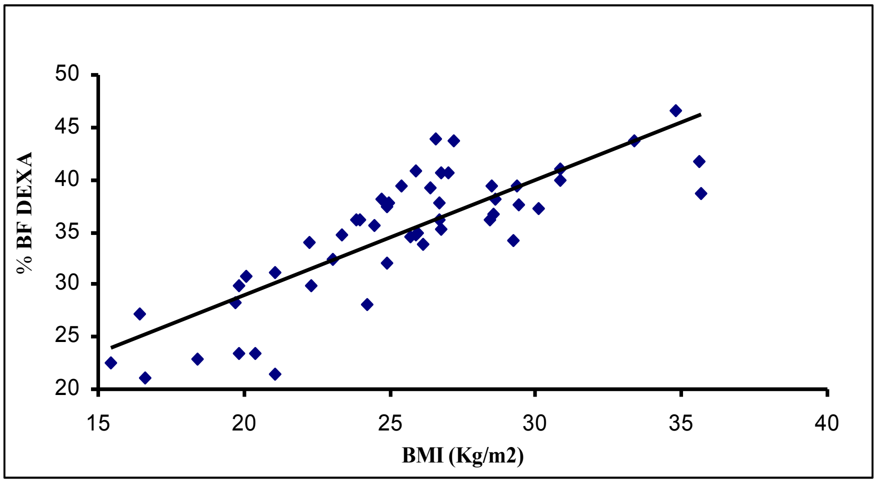
Table2. Descriptive characteristics of the female adolescents (n=51)

	Mean	SD	Range
Age (yrs)	15.06	1.67	12- 18
Height (cm)	160.18	5.5	150- 172
Weight (kg)	65.53	13.40	38.00- 97.00
BMI (kg/m^2)	25.46	4.64	15.41- 35.69
Fat-free mass (kg)	39.97	5.63	28.40- 53.82
BF (kg)	23.58	7.98	8.90- 44.25
%BF	34.93	6.21	21.00- 46.60

SD: standard deviation; BMI: body mass index; DEXA: Dual Energy X-ray Absorptiometry; BF: body fat; %BF: body fat percent.

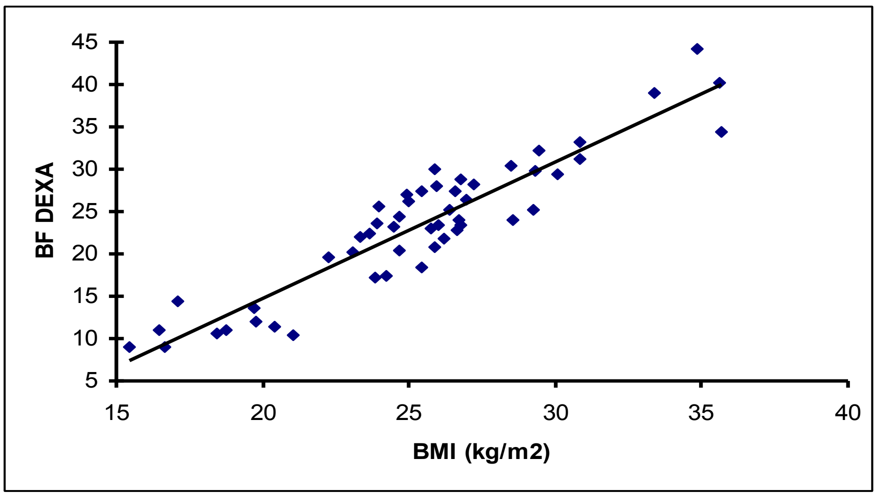
Correlation of %BF by DEXA with BMI is 0.82. Correlation of BF by DEXA with BMI is 0.93, both values at $p<0.0001$. Figure 1 shows a scatter diagram of the association between %BF by DEXA and BMI, including best fit lines for the regression of %BF on BMI. On the other hand, figure 2 shows a scatter diagram of the association between BF by DEXA and BMI. The two linear regression formulas are: %BF= 6.89 + (1.1 * BMI) and BF= -0.425 + (1.29 * BMI).

Figure1. Correlation of %BF by DEXA with BMI in girls (r=0.82, p<0.0001)



%BF: body fat percent; DEXA: Dual Energy X-ray Absorptiometry; BMI: Body Mass Index

Figure2. Correlation of Body fat by DEXA with BMI in girls (r =0.93, p<0.0001)



BF: body fat (kg); DEXA: Dual Energy X-ray Absorptiometry; BMI: Body Mass Index

DISCUSSION

This study shows that BMI is highly correlated with measures of BF obtained by DEXA. The correlations of BMI with DEXA measurements in this study group were higher with BF (r=0.93) than %BF (r=0.82). These results were similar to that reported in a study conducted in Italian children and adolescents [Pietrobelli et al., 1998].

After checking the correlations, we tried to compare %BF as estimated from the internationally accepted BMI cutoff points, and %BF as found by DEXA measurements. Most studies suggest that %BF cut off values for obesity in adolescent girls is between 30 – 35%. By using the linear regression formula obtained in our study, a BMI of 30 kg/m^2 yields a %BF of 39.89. This value falls above the accepted range. Based on the current findings, a %BF of 33 would reflect a BMI of 23 kg/m^2.

From these results we conclude that even though BMI is correlated with BF and it is used to assess obesity in epidemiological studies and initial screening, its ability to accurately estimate the degree of obesity based on %BF may be affected by several factors. In fact, a number of studies have suggested that the relationship between BMI and %BF may differ between populations. Their findings recommend the development of population specific BMI cut-off points based on age, gender, and ethnicity [WHO 2000; Wellens et al., 1996; Frankenfield et al., 2001]. Because of this, results should be interpreted with caution since the cutoff points currently used cannot detect subjects who have a higher than expected %BF for a given BMI.

One of the limitations of this study is the fact that it was conducted only in adolescent girls. However, our interest was restricted to this group because previous epidemiological studies reported very low prevalence of obesity in this population [Sibai et al., 2003 a]. Nevertheless, future studies should investigate the relation between BMI and %BF in boys

CONCLUSION

Based on the current findings, one can suggest that there is a need to lower BMI cut off point in order to more accurately assess obesity among Lebanese adolescent girls. From a public health perspective, this finding may considerably increase the prevalence of obesity among Lebanese female adolescents.

Study 3: Taking Physical Activity Level into Account Improves Body Fat Estimation in Adolescents

INTRODUCTION

Obesity has more than doubled in children and adolescents since the 1960s [Kosti et Panagiotakos 2006]. With this growing concern, several accurate measures of BF have been developed. One of these more popular methods is the BMI which is defined as weight (kg)/ height squared (m^2). Although it can only detect excess body weight rather than excess fat [Villareal et al. 2005; WHO Expert Consultation 2004], it has shown high correlations with adiposity measurements [Goran et al. 1996; Pietrobelli et al. 1998]. In parallel with this huge increase in the prevalence of obesity, studies have also shown a progressive decline in PA as a result of environmental and behavioral changes over the past fifty years [Haskell 1996; Prentice et Jebb 1995; Weinsier et al. 1998]. There is also consistent evidence that PA tends to decline during adolescence [Kann et al. 1998], especially in girls [Pate et al. 1994]. With this in mind, it is well accepted that PA has an important role in the determination of bodyweight [Obarzanek et al. 1994]. In fact, despite the methodological difficulties of assessing free living PA [Sallis et al. 1992], there is some evidence that BF may be negatively associated to PA levels [Chan et al. 2003; Delany et al. 1998].

In view of the continuous need for improving feasible and convenient measuring techniques, the primary purpose of this study was to assess the relation between BMI and BF among adolescent girls in Lebanon; the secondary purpose was, for the first time, to identify the degree to which PA may improve this relation.

SUBJECTS and METHODS

65 adolescent females participated in the study. Body weight and height were determined by standard anthropometric methods. BF was measured by DXA. PA was measured by a self-report questionnaire (Refer to phase 2 of the Research Methodology)

Statistical analysis

The means and standard deviations (SD) were calculated for all the data. Univariate correlations were given as linear regression coefficients (table 2). Multiple linear regression analysis models were used to test the relationship between %BF with BMI and PA (min/week and Met/week), as well as BF with BMI and PA (min/week and Met/week), and r^2 coefficients were reported (tables 3 and 4 respectively). Data were analyzed with NCSS (2001). A value of $p < 0.05$ was accepted as the minimal level of significance.

RESULTS

The characteristic of the study sample and assessment of body composition and PA are presented in table 1. According to age and sex, 21 females were classified as normal weight, 25 as overweight and 19 as obese based on BMI [Cole et al. 2000]. DXA whole body scans show that the normal group has an average %BF of 27.95, the overweight group has an average %BF of 37.23, and the obese group has an average %BF of 39.7

Table1. Descriptive Statistics of the Study Sample (n=65)

	Mean ± SD	Range
Age (years)	15.2 ± 2.0	12 - 18
Height (m)	1.60 ± 0.05	150 - 172
Weight (kg)	65.7 ± 13.9	38 - 97
BMI (kg/m^2)	25.5 ± 4.80	15.4 - 35.7
BF (kg)	39.9 ± 5.54	8.9 - 46.1
%BF	35.1 ± 6.34	21 - 46.8
Lean mass (kg)	39.9 ± 5.54	28.4 - 53.8
PA (min/week)	126.9 ± 64.2	40 - 250
PA (MET/week)	11 ± 6.61	3 - 27.3

BMI: Body Mass Index; BF: Body Fat; % BF: Percentage Body Fat; PA: Physical Activity

As seen in table 2, separate regression models showed that BMI was positively correlated with BF, %BF and lean mass, and negatively correlated with PA (min/week) and PA (MET/week). Moreover, PA (min/week) was negatively correlated with BF (r = -0.52) and %BF (r = -0.59) and PA (MET/week) was also correlated with BF (r = -0.52) and %BF (r = -0.52). All values were significant at p < 0.001.

Table2. Correlations of BMI Vs. measures of body composition and physical activity in female adolescents

Variable	r
BF	0.94 ***
%BF	0,84 ***
Lean mass (kg)	0.84 ***
PA (min/week)	- 0.46 ***
PA (METs/week)	- 0.51 ***

BMI: Body Mass Index; BF: Body Fat; % BF: Percentage Body Fat; PA: Physical Activity. ***: P<0.001

Table3. Multiple Regression Analysis Models with % BF as the dependent variable

Variable	Coefficient ± SE	p Value
Dependent variable %BF (r^2 = 0.76)		
Constant	14.8 ± 3.25	<0.001
BMI	0.92 ± 0.101	<0.001
PA(min/week)	-0.025 ± 0.007	0.002
Dependent variable %BF (r^2 = 0.72)		
Constant	10.98 ± 3.66	0.004
BMI	0.993 ± 0.115	<0.001
PA(METS)	-0.118 ± 0.086	0.18 ns

%BF: Percentage Body Fat; BMI: Body Mass Index; PA: Physical Activity

Table4. Multiple Regression Analysis Models with BF as the dependent variable

Variable	Coefficient ± SE	P Value
Dependent variable BF (r^2 = 0.88)		
Constant	-13.55 ± 3.15	<0.0001
BMI	1.54 ± 0.09	<0.0001
PA (min/week)	-0.01 ± 0.00	0.03
Dependent variable BF (r^2 = 0.87)		
Constant	-15.98 ± 3.39	<0.0001
BMI	1.58 ± 0.10	<0.0001
PA(METS/week)	-0.07 ± 0.08	0.33 ns

BF: Body Fat; BMI: Body Mass Index; PA: Physical Activity

Table 3 shows that BMI and PA (min/week) explained 76% of the %BF variance while table 4 shows that BMI and PA (min/week) explained 88 % of the BF variance.

DISCUSSION

As expected, our data show a high correlation between BF and %BF with BMI ($r = 0.94$ and $r = 0.84$ respectively). This finding is in accordance with previous studies that reported similar results in adolescent girls [Goulding et al. 1996; Steinberger et al. 2005].

Excess adiposity in adolescents is difficult to define especially because it may vary widely in response to age, gender and pubertal development. Most studies suggest that %BF cut off values for obesity in adolescents girls are between 30 – 35% [Sardinha et al. 1999; Taylor et al. 2002; Weststrate and Deurenberg 1989]. In our study, according to age and sex specific BMI cut off points [Cole et al. 2000], those classified as obese have an average %BF of 40.39% and those classified as overweight have an average %BF of 37.23%. This suggests that even though the relation between BMI and adiposity is highly correlated, it may vary between populations and this variation should be accounted for when assessing obesity in adolescent girls. Moreover, a previous study concluded that the ability of BMI to adequately predict BF may vary widely across youths from different countries [Eckhard et al. 2003].

Studies concerning obesity in Lebanon have suggested that PA levels are low [Sibai et al. 2003], this suggestion is confirmed in this study since our subjects reported very low PA measures. We found that PA (min/week and METs/week) was significantly and inversely associated with %BF and BF. This is in accordance with two other studies. One found that body fatness is related to energy intake and expenditure in both black and white 10 year old girls [Obarzanek et al. 1994]. The other found that percent body fat increased 0.28 percentage points less in girls with a 6.2-minute increase in Moderate to Vigorous Physical Activity (MVPA) than in girls with a 4.5-minute decrease [Stevens et al. 2007]. However, one study found that PA was independently associated with BF in boys only [Ekelund et al. 2005]. But this study used air displacement plethysmography to measure body composition and it has been shown that this technique may underestimate %BF as compared to DXA measurements [Lazzer et al. 2008; Lockner et al. 2000].

Our study was the first, to our knowledge, to investigate the effect of PA on the relation between BMI and BF measurements in Lebanese adolescent girls. Multiple linear regression showed that including PA (min/week) measurements, from the questionnaire we used, significantly improved the relation between BMI and %BF (without PA; $r^2 = 0.70$, with PA; $r^2 = 0.76$).

CONCLUSION

BMI remains the most widely used method to assess obesity. Even though more studies are required to determine the nature of the relation between BMI and %BF in adolescents and its ramifications on health, our findings suggest that by adding a simple validated self report questionnaire for PA, it may be possible to improve the relation between BMI and %BF.

GENERAL DISCUSSION

Excess adiposity is a major health concern among adults worldwide. Its prevalence is also on the rise in children and adolescents [Lobstein et al., 2004]. Of even more concern is the fact that obesity seems to track from adolescence to adulthood [Rolland-Cachera et al., 1987; Whitaker et al., 1997]. Based on this, the prevention and management of obesity during adolescence should be of primary concern.

In Lebanon, as in many other Middle Eastern countries, obesity related research is not yet viewed with the attention it deserves.

Nevertheless, in our first study, among a sample of 982 Lebanese adolescents, using widely accepted cut-off points [Cole et al., 2000] we report that the prevalence of overweight and obesity is 22.5% and 7.8% respectively in boys and 12.45% and 1.75% respectively in girls. These figures are approximate to those previously found [Sibai et al., 2003 a; Chakar and Salameh, 2006]. Based on this, it is now well established that in Lebanon, overweight and obesity is more prevalent among boys than girls. This trend is similar to that reported among adolescents in Spain [Serra Majem et al., 2003] and Greece [Tzotzas et al., 2008; Mihas et al., 2009].

Previous research has presented several factors as potential contributors to the prevalence of obesity in Lebanon. In one study, physical inactivity in the form of screen time (television viewing, videogame playing, and computer use) was proposed as a cause [Chakar and Salameh, 2006]. This suggestion was assessed in our first study. In girls, we found no difference in total screen time between the normal weight, overweight, and obese group. In boys, total screen time tended to increase as BMI increased. However, these differences were not significant. Even though many studies have reported significant associations between inactivity, precisely screen time, and obesity [Lajous et al., 2009; Laurson et al 2008], in a recent review, it was suggested that videogames and computers do not represent such a high risk for obesity [Rey-Lopez et al., 2008]. Another study which examined variables of activity, inactivity and nutrition in relation to weight status found that only vigorous physical activity was associated with weight in adolescent boys and girls [Patrick et al., 2004].

In a previous study conducted in Lebanon, lack of physical activity, defined as engaging in three or more days of leisure time physical activity per week, was significantly associated with an increased risk of being obese [Sibai et al., 2003 a]. Based on this, we assessed the relation between BMI and several variables of physical activity. Normal weight boys reported higher physical activity scores at club than the obese group. This finding is important especially since resistance training may serve a protective role against obesity by increasing FFM and decreasing BF [McGuigan et al., 2009].

Although significance was only found in girls, total physical activity tended to decline as BMI increases. This is in accordance with a study which reported that weight status among US high school students is correlated with selected physical activity behavior [Levin et al., 2003]. In fact, our finding is complemented by the fact that both obese boys and girls reported significantly lower physical functioning scores as assessed by the HRQOL questionnaire.

Obese girls reported significantly lower total and leisure physical activity scores than their normal weight peers. Several factors may explain these findings. It has been suggested that adolescent obesity is associated with low self esteem and body dissatisfaction [Fox and Farrow, 2009; Cornette 2008]. Moreover, previous studies show that obese children may suffer from discrimination by their schoolmates, and this finding is to some degree, connected with their low fitness [Malecka-Tendera et al., 1989]. These factors may possibly cause obese adolescents to shy away form participation in sports activities. In fact this may explain why all the girls in the obese group reported no participation in physical activity at clubs. This hypothesis is further supported by another study which concluded that physical activity was the least common method of loosing weight among overweight Lebanese female adolescents [Sibai et al., 2003 b].

In Lebanon, it is a general observation that PA is low. This is due to several factors. For example, only a small number of schools emphasize physical education classes and/or offer extracurricular sports activities. In a country with a high urbanization rate (81%) [WHO 2003], urban planning limits physical activity. In other words public parks and playgrounds are non existent. Moreover, fitness clubs are scarce and they may not be accessible to all.

Despite the fact that methodological limitations challenge comparability of physical activity between studies, the results of our first study are consistent with the previously described observation in that Lebanese adolescents and precisely girls, report very low levels of physical activity compared to other countries [Samdal et al., 2007]. This may be explained by several factors. Many developed countries acknowledge the importance of physical activity in promoting health and wellness and therefore physical activity is addressed in public health policies. This is not the case in third world countries. In fact, a recent review on trends in physical activity suggested that PA surveillance must be strongly encouraged in all settings and age groups and that special attention must be paid to low and middle-income countries, where PA surveillance is virtually inexistent [Knuth and Hallal, 2009]

This has led to the paradoxical outcome where the prevalence of overweight and obesity among girls is low despite reporting very low levels of physical activity.

This finding may be partially explained by several factors. First of all, nutritional issues such as lower energy intake and selection of better food choices may have an effect. Second, in today's society, girls are more conscious of their body image especially during adolescence. Third, as suggested by previous studies, self-report height and weight may be subject to certain biases, especially among overweight and obese individuals [Shields 2005; Elgar et al., 2005]. Furthermore, we cannot overlook the fact that our results were obtained using BMI which although highly correlated with body fatness, is not a direct measure of adiposity because the components of BMI include both fat mass and fat free mass. Therefore, we speculate that the low prevalence of female obesity reported in our first study may be due to a methodological misinterpretation.

The findings of our second study are in accordance with previous studies that demonstrated that BMI is correlated with body fat [Pietrobelli et al., 1998; Steinberger et al. 2005]. Therefore, BMI may be used as an indicator of obesity. However, if obesity is excess adiposity, then the question remains; how much fat should a person carry in order to be considered as obese? Based on this question, the accuracy of BMI depends on the degree to which the cut-off points can precisely estimate body fat in a given population. Several studies have shown that the relation between BMI and body fat may vary between populations. This has been demonstrated in adults [Rush et al., 2004; He et al., 2001] and in children [Eckhard et al. 2003]. In fact, a recent study conducted among 5 to 16 year old girls of varying ethnicities concluded that BMI may be used as a measure of excess fatness in girls from diverse ethnicities. However its accuracy depends on applying ethnic-specific BMI reference points [Duncan et al., 2009].

Although the BMI cut-off values that would reflect the percent body fat associated with increased risk of obesity related diseases are inconsistent, most studies suggest that percent body fat cut off values for obesity in adolescents girls is between 30 and 35% [Sardinha et al. 1999; Taylor et al. 2002; Weststrate and Deurenberg, 1989]. In our second study, according to age and sex specific BMI cut off points [Cole et al. 2000], those classified as obese have an average percent body fat of 40.39% and those classified as overweight have an average percent body fat of 37.23%. Although this finding may be possibly related to differences in body build and body type [Deurenberg et al., 2002; Deurenberg et al., 1999]. Such a high body fat at low BMI may also be partially explained from a nutritional standpoint, precisely calcium intake. A study from our laboratory reported that 89% of Lebanese female adolescents do not meet the recommended daily calcium intake [El Hage et al., 2009]. This may be related to a high body fat level, especially since it has previously been shown that low calcium intake stimulates the secretion of calciotropic hormones that cause increased intestinal calcium uptake which in turn is known to promote lipogenesis and decrease lipolysis, thus leading to increased fat mass [Zemel 2005].

Our results show that for a given BMI, Lebanese adolescent girls exhibit a higher than expected percent body fat. Therefore, using international cut-off points may lead to a significant underestimation of the prevalence of overweight and obesity among adolescent girls in Lebanon. In fact this may explain why our findings in the first study and that of previous studies reported such a low prevalence of obesity among girls despite their low levels of physical activity.

While our population sample in the second and third study is not large enough to appropriately recommend new cut-off point, our results strongly suggest the need for redefining overweight and obesity based on lower BMI cut-off points. Similar recommendations have been suggested in other studies conducted among Asian [Duncan et al., 2009] and Australian children [Wickramasinghe et al., 2005].

In the absence of other simple and feasible methods to assess body fat in large scale studies, it is highly expected that BMI will remain the most widely used method to assess obesity. Despite its convenience, its relation with body fat has been shown to be affected by factors other than those discussed previously. Physical activity is one of these factors. For example, it has been shown that highly active individuals have a greater proportion of their weigh as fat free mass and tend to accumulate less adipose tissue as compared to sedentary individuals of the same weight [Kohrt et al., 1992; Abe et al., 1996; Ode et al., 2007]. Based on this, when using BMI, these individuals may be misclassified as overweight or obese even though their body fat is within normal range. Therefore, we hypothesize that taking physical activity into account may improve the relation between BMI and body fat. In addition to the statistical analysis in the study, Backwards stepwise regression was also performed with %BF as the dependant variable. The model included BMI, age, and PA. The analysis shows that %BF can be predicted from a linear combination of BMI and PA. Moreover, age did not significantly add to the ability of the equation to predict % BF.

Our findings in the third study suggest that by adding a simple validated self report questionnaire for physical activity, it is possible to improve the relation between BMI and body fat. Even though this approach may be criticized for its subjective methodology, the use of a questionnaire to measure physical activity was intended to assess the possibility of using a simple method that may be used in parallel with BMI to more accurately assess obesity.

LIMITATIONS

There are several limitations that need to be acknowledged and addressed. First, we cannot overlook the fact that the BMI scores are based on self-reported weight and height, and therefore may be subjected to recall biases. Second, while the obtained results allow us to check for correlations between the measured variables and weight status, the cross sectional design of the study does not help to establish a cause effect relation between physical activity and obesity. Third, our findings concerning the effect of physical activity could have been reinforced by adding an objective measure of physical activity. Fourth, the studies were conducted on school-based subjects. Therefore, the derived conclusions cannot be generalized to the whole Lebanese adolescent population. Despite these limitations, this thesis includes several strengths such as the large sample size in study 1 and the utilization of validated instruments to measure physical activity and quality of life, in addition to the use of DXA which is considered by many as the current "gold standard" in assessing body composition.

CONCLUSION

In conclusion, based on currently available BMI cut-offs points, the prevalence of overweight and obesity among adolescents in Lebanon is higher for boys than girls. Boys are more active than girls, with girls reporting reduced levels of physical activity.

For a given BMI, girls reflect a higher than expected percent body fat. Based on this, the prevalence of overweight and obesity among adolescent girls is expected to be higher than previously reported. Moreover, taking physical activity into account may possibly improve the relation between BMI and body fat.

PERSPECTIVE

The findings of this thesis provide various opportunities for future research into obesity and physical activity among adolescents in Lebanon. Obviously, periodical screening of the prevalence of overweight and obesity among adolescents is required in order to monitor patterns and trends. Moreover, in parallel to our work, we also suggest that a similar study should be conducted in boys. The results of such an effort would evaluate cut-off points and help compare genders for possible differences. Also, a large scale study that establishes new BMI cut-off points in girls is highly recommended. Such a study would enable researchers to estimate obesity with more accuracy. Furthermore, the cross sectional nature of our study limits our ability to establish a cause effect relation between physical activity and obesity. Therefore, there is a need for a longitudinal study that can further increase our understanding of the relation between physical activity and obesity, possibly by using more objective methods of measuring both parameters.

BIBLIOGRAPHIC REFERENCES

Abe T, Sakurai T, Kurata J, Kawakami Y, Fukunaga T. Subcutaneous and visceral fat distribution and daily physical activity: comparison between young and middle aged women. Br J Sports Med. 30(4): 297-300, 1996.

Abell JE, Hootman JM, Zack MM, Moriarty D, Helmick CG. Physical activity and health related quality of life among people with arthritis. J Epidemiol Community Health. 59(5): 380-5, 2005.

Adamo KB, Prince SA, Tricco AC, Connor-Gorber S, Tremblay M. A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: a systematic review. Int J Pediatr Obes. 4(1): 2-27, 2009.

Ainsworth BE, Haskell WL, Leon AS, Jacobs DR Jr, Montoye HJ, Sallis JF, Paffenbarger RS Jr. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc. 25(1): 71-80, 1993 a.

Ainsworth BE, Jacobs DR Jr, Leon AS, Richardson MT, Montoye HJ. Assessment of the accuracy of physical activity questionnaire occupational data. J Occup Med.; 35(10): 1017-27, 1993 b.

Aires L, Santos R, Silva P, Santos P, Oliveira J, Ribeiro JC, Rego C, Mota J. Daily differences in patterns of physical activity among overweight/obese children engaged in a physical activity program. Am J Hum Biol. 19(6): 871-7, 2007.

Akpinar E, Bashan I, Bozdemir N, Saatci E. Which is the best anthropometric technique to identify obesity: body mass index, waist circumference or waist-hip ratio? Coll Antropol. 31(2): 387-93, 2007.

Al Mamun A, Cramb S, McDermott BM, O'Callaghan M, Najman JM, Williams GM. Adolescents' perceived weight associated with depression in young adulthood: a longitudinal study. Obesity (Silver Spring). 15(12): 3097-105, 2007.

Al Rashdan IR and Nesef YA. Prevalence of Overweight, Obesity, and Metabolic Syndrome Among Adult Kuwaitis: Results From Community-based National Survey. , 2009.

Alberti KG, Zimmet P, Shaw J; IDF Epidemiology Task Force Consensus Group. The metabolic syndrome--a new worldwide definition. Lancet. 366(9491): 1059-62, 2005.

Al-Lawati JA, Mohammed AJ, Al-Hinai HQ, Jousilahti P. Prevalence of the metabolic syndrome among Omani adults. Diabetes Care. 26(6): 1781-5, 2003.

Al-Othaimeen AI, Al-Nozha M, Osman AK. Obesity: an emerging problem in Saudi Arabia. Analysis of data from the National Nutrition Survey. East Mediterr Health J. 13(2): 441-8, 2007.

Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the Third National Health and Nutrition Examination Survey. JAMA. 279(12): 938-42, 1998.

Armstrong ME, Lambert MI, Sharwood KA, Lambert EV. Obesity and overweight in South African primary school children -- the Health of the Nation Study. S Afr Med J. 96(5): 439-44, 2006.

Armstrong N and Welsman JR. The physical activity patterns of European youth with reference to methods of assessment. Sports Med. 36(12): 1067-86, 2006.

Ashwell M, Cole TJ, Dixon AK. Obesity: new insight into the anthropometric classification of fat distribution shown by computed tomography. Br Med J (Clin Res Ed). 290(6483): 1692-4, 1985.

Bain C. Public health aspects of weight control. Commentary: What's past is prologue. Int J Epidemiol. 35(1):10-2; discussion 12-4, 2006.

Balarajan Y and Villamor E. Nationally representative surveys show recent increases in the prevalence of overweight and obesity among women of reproductive age in Bangladesh, Nepal, and India. J Nutr. 139(11): 2139-44, 2009.

Balkau B, Deanfield JE, Després JP, Bassand JP, Fox KA, Smith SC Jr, Barter P, Tan CE, Van Gaal L, Wittchen HU, Massien C, Haffner SM. International Day for the Evaluation of Abdominal Obesity (IDEA): a study of waist circumference, cardiovascular disease, and diabetes mellitus in 168,000 primary care patients in 63 countries. Circulation. 116(17): 1942-51, 2007.

Bandini LG, Schoeller DA, Cyr HN, Dietz WH. Validity of reported energy intake in obese and nonobese adolescents. Am J Clin Nutr. 52 (3): 421-5, 1990 a.

Bandini LG, Schoeller DA, Dietz WH. Energy expenditure in obese and nonobese adolescents. Pediatr Res. 27(2): 198-203, 1990 b.

Bao W, Srinivasan SR, Valdez R, Greenlund KJ, Wattigney WA, Berenson GS. Longitudinal changes in cardiovascular risk from childhood to young adulthood in offspring of parents with coronary artery disease: the Bogalusa Heart Study. JAMA. 278(21): 1749-54, 1997.

Bassett DR Jr, Fitzhugh EC, Crespo CJ, King GA, McLaughlin JE. Physical activity and ethnic differences in hypertension prevalence in the United States. Prev Med. 34(2): 179-86, 2002.

Batada A, Seitz MD, Wootan MG, Story M. Nine out of 10 food advertisements shown during Saturday morning children's television programming are for foods high in fat, sodium, or added sugars, or low in nutrients. J Am Diet Assoc. 108(4): 673-8, 2008.

Battle EK and Brownell KD. Confronting a rising tide of eating disorders and obesity: treatment vs. prevention and policy. Addict Behav. 21(6): 755-65, 1996.

Bélanger-Ducharme F and Tremblay A. Prevalence of obesity in Canada. Obes Rev. 6(3): 183-6, 2005.

Bener A and Tewfik I. Prevalence of overweight, obesity, and associated psychological problems in Qatari's female population. Obes Rev. 7(2): 139-45, 2006.

Bener A. Prevalence of obesity, overweight, and underweight in Qatari adolescents. Food Nutr Bull. 27(1): 39-45, 2006.

Binkley JK, Eales J, Jekanowski M. The relation between dietary change and rising US obesity. Int J Obes Relat Metab Disord. 24(8): 1032-9, 2000.

Birmingham CL, Muller JL, Palepu A, Spinelli JJ, Anis AH. The cost of obesity in Canada. CMAJ. 160(4): 483-8, 1999.

Blair SN and Brodney S. Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. Med Sci Sports Exerc. 31(11 Suppl): S646-62, 1999.

Blair SN, Applegate WB, Dunn AL, Ettinger WH, Haskell WL, King AC, Morgan TM, Shih JA, Simons-Morton DG. Activity Counseling Trial (ACT): rationale, design, and methods. Activity Counseling Trial Research Group. Med Sci Sports Exerc. 30(7): 1097-106, 1998.

Blew RM, Sardinha LB, Milliken LA, Teixeira PJ, Going SB, Ferreira DL, Harris MM, Houtkooper LB, Lohman TG. Assessing the validity of body mass index standards in early postmenopausal women. Obes Res. 10(8): 799-808, 2002.

Bokor S, Frelut ML, Vania A, Hadjiathanasiou CG, Anastasakou M, Malecka-Tendera E, Matusik P, Molnár D. Prevalence of metabolic syndrome in European obese children. Int J Pediatr Obes. 3 Suppl 2: 3-8, 2008.

Bonnefoy M, Normand S, Pachiaudi C, Lacour JR, Laville M, Kostka T. Simultaneous validation of ten physical activity questionnaires in older men: a doubly labeled water study. J Am Geriatr Soc. 49(1): 28-35, 2001.

Borraccino A, Lemma P, Iannotti RJ, Zambon A, Dalmasso P, Lazzeri G, Giacchi M, Cavallo F. Socioeconomic effects on meeting physical activity guidelines: comparisons among 32 countries. Med Sci Sports Exerc. 41(4): 749-56, 2009.

Bouchard C, Pérusse L, Leblanc C, Tremblay A, Thériault G. Inheritance of the amount and distribution of human body fat. Int J Obes. 12(3): 205-15, 1988.

Bowman SA and Vinyard BT. Fast food consumption of U.S. adults: impact on energy and nutrient intakes and overweight status. J Am Coll Nutr. 23(2): 163-8, 2004.

Brage S, Brage N, Franks PW, Ekelund U, Wong MY, Andersen LB, Froberg K, Wareham NJ. Branched equation modeling of simultaneous accelerometry and heart rate monitoring improves estimate of directly measured physical activity energy expenditure. J Appl Physiol. 96(1): 343-51, 2004.

Brage S, Wedderkopp N, Franks PW, Andersen LB, Froberg K. Reexamination of validity and reliability of the CSA monitor in walking and running. Med Sci Sports Exerc. 35(8): 1447-54, 2003.

Bray GA. Obesity: historical development of scientific and cultural ideas. Int J Obes.14(11): 909-26, 1990.

Breslow L. Public health aspects of weight control. 1952. Int J Epidemiol. 35(1): 10-2; discussion 12-4, 2006.

Brown CD, Higgins M, Donato KA, Rohde FC, Garrison R, Obarzanek E, Ernst ND, Horan M. Body mass index and the prevalence of hypertension and dyslipidemiaObes Res. 8(9): 605-19, 2000.

Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: what are the contributors? Annu Rev Public Health. 26: 421-43, 2005.

Brozek J, Grande F, Anderson JT, Keys A. Densitometric Analysis of Body Composition: Revision of Some Quantitative Assumptions. Ann N Y Acad Sci. 110: 113-40, 1963.

Burton BT and Foster WR. Health implications of obesity: an NIH Consensus Development Conference. J Am Diet Assoc. 85(9): 1117-21, 1985.

Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep. 100(2): 126-31, 1985.

Cavadini C, Siega-Riz AM, Popkin BM. US adolescent food intake trends from 1965 to 1996. Arch Dis Child. 83(1): 18-24, 2000.

CDC, National Diabetes Fact Sheet. United States, 2005. Available at: http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2005.pdf. Accessed December 5, 2008.

Chakar H and Salameh PR. Adolescent obesity in Lebanese private schools. Eur J Public Health. 16(6): 648-51, 2006.

Chamney PW, Wabel P, Moissl UM, Müller MJ, Bosy-Westphal A, Korth O, Fuller NJ. A whole-body model to distinguish excess fluid from the hydration of major body tissues. Am J Clin Nutr. 85(1): 80-9, 2007.

Chang CJ, Wu CH, Chang CS, Yao WJ, Yang YC, Wu JS, Lu FH. Low body mass index but high percent body fat in Taiwanese subjects: implications of obesity cutoffs. Int J Obes Relat Metab Disord. 27(2): 253-9, 2003.

Chinn S, Rona RJ, Gulliford MC, Hammond J Weight-for-height in children aged 4-12 years. A new index compared to the normalized body mass index. Eur J Clin Nutr. 46(7): 489-500, 1992.

Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension. 42(6): 1206-52, 2003.

Cicuttini FM, Baker JR, Spector TD. The association of obesity with osteoarthritis of the hand and knee in women: a twin study. J Rheumatol. 23(7): 1221-6, 1996.

Colditz GA, Willett WC, Rotnitzky A, Manson JE. Weight gain as a risk factor for clinical diabetes mellitus in women. Ann Intern Med. 122(7): 481-6, 1995.

Colditz GA, Willett WC, Stampfer MJ, Manson JE, Hennekens CH, Arky RA, Speizer FE. Weight as a risk factor for clinical diabetes in women. Am J Epidemiol. 132(3): 501-13, 1990.

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 320(7244): 1240-3, 2000.

Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988-1994. Arch Pediatr Adolesc Med. 157(8): 821-7, 2003.

Cordero-MacIntyre ZR, Peters W, Libanati CR, España RC, Abila SO, Howell WH, Lohman TG. Reproducibility of DXA in obese women. J Clin Densitom. 5(1): 35-44, 2002.

Cornette R. The emotional impact of obesity on children. Worldviews Evid Based Nurs. 5(3): 136-41, 2008.

Coyne T. Lifestyle Diseases in Pacific Communities. New Caledonia, Secretariat of the Pacific Community. SPC technical paper (Secretariat of the Pacific Community); no. 219, 2000. Available at http://catalogue.nla.gov.au/Record/3042766. Accessed on December 7, 2009.

Crespo CJ, Smit E, Troiano RP, Bartlett SJ, Macera CA, Andersen RE. Television watching, energy intake, and obesity in US children: results from the third National Health and Nutrition Examination Survey, 1988-1994. Arch Pediatr Adolesc Med. 155(3): 360-5, 2001.

Cruz ML, Weigensberg MJ, Huang TT, Ball G, Shaibi GQ, Goran MI. The metabolic syndrome in overweight Hispanic youth and the role of insulin sensitivity. J Clin Endocrinol Metab. 89(1): 108-13, 2004.

da Rocha EE, Alves VG, da Fonseca RB. Indirect calorimetry: methodology, instruments and clinical application.Curr Opin Clin Nutr Metab Care. 9(3): 247-56, 2006.

Davey RC. The obesity epidemic: too much food for thought? Br J Sports Med. 38(3): 360-3, 2004.

Davis MA, Neuhaus JM, Ettinger WH, Mueller WH. Body fat distribution and osteoarthritis. Am J Epidemiol. 132(4): 701-7, 1990.

de Koning L, Merchant AT, Pogue J, Anand SS. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. Eur Heart J. 28(7): 850-6, 2007.

de Onis M, Habicht JP. Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. Am J Clin Nutr. 64(4): 650-8, 1996.

Deheeger M, Rolland-Cachera MF, Fontvieille AM. Physical activity and body composition in 10 year old French children: linkages with nutritional intake? Int J Obes Relat Metab Disord 21:372-379, 1997.

Dekker JM, Girman C, Rhodes T, Nijpels G, Stehouwer CD, Bouter LM, Heine RJ. Metabolic syndrome and 10-year cardiovascular disease risk in the Hoorn Study. Circulation. 112(5): 666-73, 2005.

Dempster P, Aitkens S. A new air displacement method for the determination of human body composition. Med Sci Sports Exerc. 27(12): 1692-7, 1995.

Denke MA, Sempos CT, Grundy SM. Excess body weight. An under-recognized contributor to dyslipidemia in white American women. Arch Intern Med. 154(4): 401-10. 1994.

Denke MA, Sempos CT, Grundy SM. Excess body weight. An underrecognized contributor to high blood cholesterol levels in white American men. Arch Intern Med. 153(9): 1093-103, 1993.

Després JP, Moorjani S, Lupien PJ, Tremblay A, Nadeau A, Bouchard C. Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. Arteriosclerosis. 10(4): 497-511, 1990.

Deurenberg P and **Deurenberg-Yap M**. Differences in body-composition assumptions across ethnic groups: practical consequences. Curr Opin Clin Nutr Metab Care. 4(5): 377-83, 2001.

Deurenberg P, Deurenberg Yap M, Wang J, Lin FP, Schmidt G. The impact of body build on the relationship between body mass index and percent body fat. Int J Obes Relat Metab Disord. 23(5): 537-42, 1999.

Deurenberg P, Deurenberg-Yap M, Guricci S. Asians are different from Caucasians and from each other in their body mass index/body fat per cent relationship. Obes Rev. 3(3): 141-6, 2002.

Deurenberg P, Weststrate JA, Seidell JC. Body mass index as a measure of body fatness: age- and sex-specific prediction formulas. Br J Nutr. 65(2): 105-14, 1991.

Deurenberg-Yap M, Schmidt G, van Staveren WA, Deurenberg P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. Int J Obes Relat Metab Disord. 24(8) :1011-7, 2000.

Diehl AK. Epidemiology and natural history of gallstone disease. Gastroenterol Clin North Am. 20(1) :1-19, 1991.

Dietz WH and Robinson TN. Use of the body mass index (BMI) as a measure of overweight in children and adolescents. J Pediatr. 132(2): 191-3, 1998.

Dietz WH Jr, Gross WL, Kirkpatrick JA Jr. Blount disease (tibia vara): another skeletal disorder associated with childhood obesity. J Pediatr. 101(5): 735-7, 1982.

Drewnowski A, Greenwood MR. Cream and sugar: human preferences for high-fat foods. Physiol Behav. 30(4): 629-33, 1983.

Drewnowski A, Kurth C, Holden-Wiltse J, Saari J. Food preferences in human obesity: carbohydrates versus fats. Appetite. 18(3): 207-21, 1992.

Dumanovsky T, Nonas CA, Huang CY, Silver LD, Bassett MT. What people buy from fast-food restaurants: caloric content and menu item selection, New York City 2007. Obesity (Silver Spring). 17(7): 1369-74, 2009.

Duncan JS, Duncan EK, Schofield G. Accuracy of body mass index (BMI) thresholds for predicting excess body fat in girls from five ethnicities. Asia Pac J Clin Nutr. 18(3): 404-11, 2009.

DuRant RH, Baranowski T, Johnson M, Thompson WO. The relationship among television watching, physical activity, and body composition of young children. Pediatrics. 94(4 Pt 1): 449-55, 1994.

Durnin JV and Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr. 32(1): 77-97, 1974.

Dyer AR and Elliott P. The INTERSALT study: relations of body mass index to blood pressure. INTERSALT Co-operative Research Group. J Hum Hypertens. 3(5): 299-308, 1989.

Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. Lancet. 360(9331): 473-82, 2002.

Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. Lancet. 365(9468): 1415-28, 2005.

Eckhardt CL, Adair LS, Caballero B, Avila J, Kon IY, Wang J, Popkin BM. Estimating body fat from anthropometry and isotopic dilution: a four-country comparison. Obes Res. 11(12): 1553-62, 2003.

Ekelund U, Aman J, Yngve A, Renman C, Westerterp K, Sjöström M. Physical activity but not energy expenditure is reduced in obese adolescents: a case-control study. Am J Clin Nutr. 76(5): 935-41, 2002.

Ekelund U, Anderssen S, Andersen LB, Riddoch CJ, Sardinha LB, Luan J, Froberg K, Brage S. Prevalence and correlates of the metabolic syndrome in a population-based sample of European youth. Am J Clin Nutr. 89(1): 90-6, 2009.

Ekelund U, Poortvliet E, Yngve A, Hurtig-Wennlöv A, Nilsson A, Sjöström M. Heart rate as an indicator of the intensity of physical activity in human adolescents. Eur J Appl Physiol. 85(3-4): 244-9, 2001.

Eknoyan G. Adolphe Quetelet (1796-1874)--the average man and indices of obesity. Nephrol Dial Transplant. 23(1): 47-51, 2008.

Elgar FJ, Roberts C, Tudor-Smith C, Moore L. Validity of self-reported height and weight and predictors of bias in adolescents. J Adolesc Health. 37(5): 371-5, 2005

El Hage R, Jacob C, Moussa E, Jaffré C, Benhamou CL.. Daily calcium intake and body mass index in a group of Lebanese adolescents. J Med Liban. 57(4): 253-7, 2009.

El-Bayoumy I, Shady I, Lotfy H. Prevalence of obesity among adolescents (10 to 14 years) in Kuwait. Asia Pac J Public Health. 21(2): 153-9, 2009.

Epstein LH, Wing RR, Cluss P, Fernstrom MH, Penner B, Perkins KA, Nudelman S, Marks B, Valoski A. Resting metabolic rate in lean and obese children: relationship to child and parent weight and percent-overweight change. Am J Clin Nutr. 49(2): 331-6, 1989.

Eriksson KF and Lindgärde F. Poor physical fitness, and impaired early insulin response but late hyperinsulinaemia, as predictors of NIDDM in middle-aged Swedish men. Diabetologia. 39(5): 573-9, 1996.

Everhart JE. Contributions of obesity and weight loss to gallstone disease. Ann Intern Med. 119(10): 1029-35, 1993.

Farshchi HR, Taylor MA, Macdonald IA. Deleterious effects of omitting breakfast on insulin sensitivity and fasting lipid profiles in healthy lean women. Am J Clin Nutr. 81(2): 388-96, 2005.

Felson DT, Anderson JJ, Naimark A, Walker AM, Meenan RF. Obesity and knee osteoarthritis. The Framingham Study. Ann Intern Med. 109(1): 18-24, 1988.

Felson DT, Zhang Y, Hannan MT, Naimark A, Weissman B, Aliabadi P, Levy D. Risk factors for incident radiographic knee osteoarthritis in the elderly: the Framingham Study. Arthritis Rheum. 40(4): 728-33, 1997.

Fernstrom MH and Courcoulas AP. Bariatric surgery for the severely obese adolescent. Aesthet Surg J. 28(3): 331-4, 2008.

Filozof C, Gonzalez C, Sereday M, Mazza C, Braguinsky J. Obesity prevalence and trends in Latin-American countries. Obes Rev. 2(2): 99-106, 2001.

Fomon SJ, Haschke F, Ziegler EE, Nelson SE. Body composition of reference children from birth to age 10 years. Am J Clin Nutr. 35(5 Suppl): 1169-75, 1982.

Fontvieille AM, Dwyer J, Ravussin E. Resting metabolic rate and body composition of Pima Indian and Caucasian children. Int J Obes Relat Metab Disord. 16(8): 535-42, 1992.

Ford ES and Mokdad AH. Epidemiology of obesity in the Western Hemisphere. J Clin Endocrinol Metab. 93(11 Suppl 1): S1-8, 2008.

Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. JAMA. 287(3): 356-9, 2002.

Ford ES. Risks for all-cause mortality, cardiovascular disease, and diabetes associated with the metabolic syndrome: a summary of the evidence. Diabetes Care. 28(7): 1769-78, 2005.

Fox CL and Farrow CV. Global and physical self-esteem and body dissatisfaction as mediators of the relationship between weight status and being a victim of bullying. J Adolesc. 32(5): 1287-301, 2009.

Fransen M, Nairn L, Winstanley J, Lam P, Edmonds J Physical activity for osteoarthritis management: a randomized controlled clinical trial evaluating hydrotherapy or Tai Chi classes. Arthritis Rheum. 57(3): 407-14, 2007.

Freedman DS, Wang J, Thornton JC, Mei Z, Pierson RN Jr, Dietz WH, Horlick M. Racial/ethnic differences in body fatness among children and adolescents. Obesity (Silver Spring). 16(5): 1105-11, 2008.

Freedson P, Pober D, Janz KF. Calibration of accelerometer output for children. Med Sci Sports Exerc. 37(11 Suppl): S523-30, 2005.

Friedlander SL, Larkin EK, Rosen CL, Palermo TM, Redline S. Decreased quality of life associated with obesity in school-aged children. Arch Pediatr Adolesc Med. 157(12): 1206-11, 2003.

Gallagher D, Visser M, Sepúlveda D, Pierson RN, Harris T, Heymsfield SB. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? Am J Epidemiol. 143(3): 228-39, 1996.

Garfinkel L. Overweight and cancer. Ann Intern Med. 103(6 (Pt 2)): 1034-6, 1985.

Garn SM and Pesick SD. Comparison of the Benn index and other body mass indices in nutritional assessment. Am J Clin Nutr. 36(4): 573-5, 1982.

Garrow JS and Webster J. Quetelet's index (W/H2) as a measure of fatness. Int J Obes. 9(2): 147-53, 1985.

Gayle R, Montoye HJ, Philpot J. Accuracy of pedometers for measuring distance walked. Res Q. 48(3): 632-6, 1977.

Gelber AC, Hochberg MC, Mead LA, Wang NY, Wigley FM, Klag MJ. Body mass index in young men and the risk of subsequent knee and hip osteoarthritis. Am J Med. 107(6): 542-8, 1999.

Gibson LY, Byrne SM, Blair E, Davis EA, Jacoby P, Zubrick SR. Clustering of psychosocial symptoms in overweight children. Aust N Z J Psychiatry. 42(2): 118-25, 2008.

Glueck CJ, Taylor HL, Jacobs D, Morrison JA, Beaglehole R, Williams OD. Plasma high-density lipoprotein cholesterol: association with measurements of body mass. The Lipid Research Clinics Program Prevalence Study. Circulation. 62(4 Pt 2): IV-62-9, 1980.

Goins RT, Spencer SM, Krummel DA. Effect of obesity on health-related quality of life among Appalachian elderly. South Med J. 96(6): 552-7, 2003.

Golay A and Ybarra J. Link between obesity and type 2 diabetes. Best Pract Res Clin Endocrinol Metab. 19(4): 649-63, 2005.

Goran MI, Driscoll P, Johnson R, Nagy TR, Hunter G. Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. Am J Clin Nutr. 63(3): 299-305, 1996.

Goran MI, Gower BA, Treuth M, Nagy TR. Prediction of intra-abdominal and subcutaneous abdominal adipose tissue in healthy pre-pubertal children. Int J Obes Relat Metab Disord. 22(6): 549-58, 1998.

Goran MI, Hunter G, Nagy TR, Johnson R. Physical activity related energy expenditure and fat mass in young children. Int J Obes Relat Metab Disord. 21(3): 171-8, 1997.

Goran MI. Measurement issues related to studies of childhood obesity: assessment of body composition, body fat distribution, physical activity, and food intake. Pediatrics. 101(3 Pt 2): 505-18, 1998.

Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. Arch Pediatr Adolesc Med. 150(4): 356-62, 1996.

Gortmaker SL, Peterson K, Wiecha J, Sobol AM, Dixit S, Fox MK, Laird N. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. Arch Pediatr Adolesc Med. 153(4): 409-18, 1999.

Goulding A, Gold E, Cannan R, Taylor RW, Williams S, Lewis-Barned NJ. DEXA supports the use of BMI as a measure of fatness in young girls. Int J Obes Relat Metab Disord. 20(11): 1014-21, 1996.

Gray DS, Bray GA, Bauer M, Kaplan K, Gemayel N, Wood R, Greenway F, Kirk S. Skinfold thickness measurements in obese subjects. Am J Clin Nutr. 51(4): 571-7, 1990.

Gupta R, Deedwania PC, Gupta A, Rastogi S, Panwar RB, Kothari K. Prevalence of metabolic syndrome in an Indian urban population. Int J Cardiol. 97(2): 257-61, 2004.

Gutin B, Basch C, Shea S, Contento I, DeLozier M, Rips J, Irigoyen M, Zybert P. Blood pressure, fitness, and fatness in 5- and 6-year-old children. JAMA. 264(9): 1123-7, 1990.

Gutin B, Litaker M, Islam S, Manos T, Smith C, Treiber F. Body-composition measurement in 9-11-y-old children by dual-energy X-ray absorptiometry, skinfold-thickness measurements, and bioimpedance analysis. Am J Clin Nutr. 63(3): 287-92. 1996.

Hanley AJ, Harris SB, Gittelsohn J, Wolever TM, Saksvig B, Zinman B. Overweight among children and adolescents in a Native Canadian community: prevalence and associated factors. Am J Clin Nutr. 71(3): 693-700, 2000.

Haslam DW and James WP. Obesity. Lancet. 366(9492): 1197-209, 2005.

He M, K C B Tan, E T S L, et al. Body fat determination by dual energy X-ray absorptiometry and its relation to body mass index and waist circumference in Hong Kong Chinese. Int J Obesity. 25: 748-52, 2001.

Helmrich SP, Ragland DR, Leung RW, Paffenbarger RS Jr. Physical activity and reduced occurrence of non-insulin-dependent diabetes mellitus. N Engl J Med. 325(3): 147-52, 1991.

Hertogh EM, Monninkhof EM, Schouten EG, Peeters PH, Schuit AJ. Validity of the Modified Baecke Questionnaire: comparison with energy expenditure according to the doubly labeled water method. Int J Behav Nutr Phys Act. 5: 30, 2008.

Heymsfield SB, Shen W, Wang J. Chapter 2. Evaluation of total and regional adiposity. In: Bray G, Bouchard C, James P, eds. Handbook of Obesity. New York: Dekker; 1998

Hill AJ, Silver EK. Fat, friendless and unhealthy: 9-year old children's perception of body shape stereotypes. Int J Obes Relat Metab Disord. 19(6): 423-30, 1995.

Hill J.O., M.J. Pagliassotti, and J.C. Peters. Non-genetic determinants of obesity and fat topography. In Genetic Determinants of Obesity, ed. C. Bouchard, 35-48. Boca Raton: CRC Press, inc, 1994.

Hochberg MC, Lethbridge-Cejku M, Plato CC, Wigley FM, Tobin JD. Factors associated with osteoarthritis of the hand in males: data from the Baltimore Longitudinal Study of Aging. Am J Epidemiol. 134(10): 1121-7, 1991.

Hochberg MC, Lethbridge-Cejku M, Scott WW Jr, Plato CC, Tobin JD. Obesity and osteoarthritis of the hands in women. Osteoarthritis Cartilage. 1(2): 129-35, 1993.

Hochberg MC, Lethbridge-Cejku M, Scott WW Jr, Reichle R, Plato CC, Tobin JD. The association of body weight, body fatness and body fat distribution with osteoarthritis of the knee: data from the Baltimore Longitudinal Study of Aging. J Rheumatol. 22(3): 488-93, 1995.

Hood MY, Moore LL, Sundarajan-Ramamurti A, Singer M, Cupples LA, Ellison RC. Parental eating attitudes and the development of obesity in children. The Framingham Children's Study. Int J Obes Relat Metab Disord. 24(10):1319-25, 2000.

Horlick M. Body mass index in childhood--measuring a moving target. J Clin Endocrinol Metab. 86(9): 4059-60, 2001.

Horton ES. Introduction: an overview of the assessment and regulation of energy balance in humans. Am J Clin Nutr. 38(6):972-7, 1983.

Hu FB, Leitzmann MF, Stampfer MJ, Colditz GA, Willett WC, Rimm EB. Physical activity and television watching in relation to risk for type 2 diabetes mellitus in men. Arch Intern Med. 161(12): 1542-8, 2001 a.

Hu FB, Li TY, Colditz GA, Willett WC, Manson JE. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. JAMA. 289(14): 1785-91, 2003.

Hu FB, Manson JE, Stampfer MJ, Colditz G, Liu S, Solomon CG, Willett WC. Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. N Engl J Med. 345(11): 790-7, 2001 b.

Hu FB, Stampfer MJ, Solomon C, Liu S, Colditz GA, Speizer FE, Willett WC, Manson JE. Physical activity and risk for cardiovascular events in diabetic women. Ann Intern Med. 134(2): 96-105, 2001 c.

Huang IC, Frangakis C, Wu AW. The relationship of excess body weight and health-related quality of life: evidence from a population study in Taiwan. Int J Obes (Lond). 30(8): 1250-9, 2006.

Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. Circulation. 67(5): 968-77, 1983.

International Association for the Study of Obesity. London, 2008. Available at http://www.iotf.org/database/documents/v2PDFforwebsiteEU27.pdf. Accessed on December 5, 2009.

International Association for the Study of Obesity. London, 2009. Available at http://www.iotf.org/database/documents/ChildEU27ECO2009pdf. Accessed on December 4, 2009.

Ismail MN, Chee SS, Nawawi H, Yusoff K, Lim TO, James WP. Obesity in Malaysia. Obes Rev. 3(3): 203-8, 2002.

Janghorbani M, Amini M, Willett WC, Mehdi Gouya M, Delavari A, Alikhani S, Mahdavi A. First nationwide survey of prevalence of overweight, underweight, and abdominal obesity in Iranian adults. Obesity (Silver Spring). 15(11): 2797-808, 2007.

Janz KF, Nielsen DH, Cassady SL, Cook JS, Wu YT, Hansen JR. Cross-validation of the Slaughter skinfold equations for children and adolescents. Med Sci Sports Exerc. 25(9): 1070-6, 1993.

Jarret RJ. Is there and ideal body weight? Br Med J (Clin Res Ed). 293(6545): 493-5, 1986.

Ji CY, Sun JL, Chen TJ. [Dynamic analysis on the prevalence of obesity and overweight school-age children and adolescents in recent 15 years in China] Zhonghua Liu Xing Bing Xue Za Zhi. 25(2): 103-8, 2004.

Kaechele V, Wabitsch M, Thiere D, Kessler AL, Haenle MM, Mayer H, Kratzer W. Prevalence of gallbladder stone disease in obese children and adolescents: influence of the degree of obesity, sex, and pubertal development. J Pediatr Gastroenterol Nutr. 42(1): 66-70, 2006.

Kann L, Kinchen SA, Williams BI, Ross JG, Lowry R, Hill CV, Grunbaum JA, Blumson PS, Collins JL, Kolbe LJ. Youth risk behavior surveillance--United States, 1997. MMWR CDC Surveill Summ. 47(3): 1-89, 1998.

Kappagoda CT, Linden RJ, Newell JP. Effect of the Canadian Air Force training programme on a submaximal exercise test. Q J Exp Physiol Cogn Med Sci. 64(3): 185-204, 1979.

Katzmarzyk PT. The Canadian obesity epidemic: an historical perspective. Obes Res. 10(7): 666-74, 2002.

Keke K, Phongsavan P, Dan L, Bacigalupo M, Smith B, Thoma R, Riley L, Waidubu G, Galea G, Pryor J, Raj S, Chey T. World Health Organization, Western Pacific Region. Nauru NCD risk factors STEPS report. Suva, Fiji, 2007. Available at http://www.who.int/chp/steps/Printed_STEPS_Report_Nauru.pdf. Accessed on November 29, 2009.

Kemper HC and Verschuur R. Validity and reliability of pedometers in habitual activity research. Eur J Appl Physiol Occup Physiol. 37(1): 71-82, 1977.

Keresztes N, Piko BF, Pluhar ZF, Page RM. Social influences in sports activity among adolescents. J R Soc Promot Health. 128(1) :21-5, 2008.

Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL. Indices of relative weight and obesity. J Chronic Dis. 25(6): 329-43, 1972.

Khader Y, Irshaidat O, Khasawneh M, Amarin Z, Alomari M, Batieha A. Overweight and obesity among school children in Jordan: prevalence and associated factors. Matern Child Health J. 13(3):424-31., 2009.

King KA, Tergerson JL, Wilson BR. Effect of social support on adolescents' perceptions of and engagement in physical activity. J Phys Act Health. 5(3): 374-84, 2008.

Kipke MD, Iverson E, Moore D, Booker C, Ruelas V, Peters AL, Kaufman F. Food and park environments: neighborhood-level risks for childhood obesity in east Los Angeles. J Adolesc Health. 40(4): 325-33, 2007.

Klesges RC, Coates TJ, Brown G, Sturgeon-Tillisch J, Moldenhauer-Klesges LM, Holzer B, Woolfrey J, Vollmer J. Parental influences on children's eating behavior and relative weight. J Appl Behav Anal. 16(4): 371-8, 1983.

Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, Nathan DM; Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med. 346(6): 393-403, 2002.

Knuth AG and Hallal PC. Temporal trends in physical activity: a systematic review. J Phys Act Health. 6(5): 548-59, 2009.

Kohrt WM, Malley MT, Dalsky GP, Holloszy JO. Body composition of healthy sedentary and trained, young and older men and women. Med Sci Sports Exerc. 24(7): 832-7, 1992.

Kolotkin RL, Crosby RD, Williams GR, Hartley GG, Nicol S. The relationship between health-related quality of life and weight loss. Obes Res. 9(9): 564-71, 2001.

Kopelman PG. Obesity as a medical problem. Nature. 404(6778): 635-43, 2000.

Koster A, Leitzmann MF, Schatzkin A, Mouw T, Adams KF, van Eijk JT, Hollenbeck AR, Harris TB. Waist circumference and mortality. Am J Epidemiol. 167(12): 1465-75, 2008.

Kosti RI and Panagiotakos DB. The epidemic of obesity in children and adolescents in the world. Cent Eur J Public Health. 14(4): 151-9, 2006.

Kotz K, Story M. Food advertisements during children's Saturday morning television programming: are they consistent with dietary recommendations? J Am Diet Assoc. 94(11): 1296-300, 1994.

Kriska AM, Knowler WC, Hall CB, LaPorte RE, Drash AL, Wing RR, Blair S, Bennett PH, Kuller LH. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. Diabetes Care. 13(4): 401-11, 1990.

Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Manuel Gómez J, et al. Bioelectrical impedance analysis-part II: utilization in clinical practice. Clin Nutr. 23(6): 1430-53, 2004.

Lajous M, Chavarro J, Peterson KE, Hernández-Prado B, Cruz-Valdéz A, Hernández-Avila M, Lazcano-Ponce E. Screen time and adiposity in adolescents in Mexico. Public Health Nutr. 12(10): 1938-45, 2009.

Lamb KL and Brodie DA. The assessment of physical activity by leisure-time physical activity questionnaires. Sports Med. 10(3): 159-80, 1990.

Lamonte MJ and Ainsworth BE. Quantifying energy expenditure and physical activity in the context of dose response. Med Sci Sports Exerc. 33(6 Suppl): S370-8; discussion S419-20, 2001.

LaPorte RE, Montoye HJ, Caspersen CJ. Assessment of physical activity in epidemiologic research: problems and prospects. Public Health Rep. 100(2): 131-46, 1985.

Lauer RM, Connor WE, Leaverton PE, Reiter MA, Clarke WR. Coronary heart disease risk factors in school children: the Muscatine study. J Pediatr. 86(5): 697-706, 1975.

Lauer RM, Lee J, Clarke WR. Factors affecting the relationship between childhood and adult cholesterol levels: the Muscatine Study. Pediatrics. 82(3): 309-18, 1988.

Laurson KR, Eisenmann JC, Welk GJ, Wickel EE, Gentile DA, Walsh DA. Combined influence of physical activity and screen time recommendations on childhood overweight. J Pediatr. 153(2): 209-14, 2008.

Lazzer S, Bedogni G, Agosti F, De Col A, Mornati D, Sartorio A. Comparison of dual-energy X-ray absorptiometry, air displacement plethysmography and bioelectrical impedance analysis for the assessment of body composition in severely obese Caucasian children and adolescents. Br J Nutr. 100(4):918-24, 2008.

Lee CD, Blair SN, Jackson AS. Cardiorespiratory fitness, body composition, and all-cause and cardiovascular disease mortality in men. Am J Clin Nutr. 69(3): 373-80, 1999.

Lee SA, Wen W, Xu WH, Zheng W, Li H, Yang G, Xiang YB, Shu XO. Prevalence of obesity and correlations with lifestyle and dietary factors in Chinese men. Obesity (Silver Spring). 16(6): 1440-7, 2008.

Levin S, Lowry R, Brown DR, Dietz WH. Physical activity and body mass index among US adolescents: youth risk behavior survey, 1999. Arch Pediatr Adolesc Med. 157(8): 816-20, 2003.

Lewis MK and Hill AJ. Food advertising on British children's television: a content analysis and experimental study with nine-year olds. Int J Obes Relat Metab Disord. 22(3): 206-14, 1998.

Ley CJ, Lees B, Stevenson JC. Sex- and menopause-associated changes in body-fat distribution. Am J Clin Nutr. 55(5): 950-4, 1992.

Li Y, Yang X, Zhai F, Kok FJ, Zhao W, Piao J, Zhang J, Cui Z, Ma G. Prevalence of the metabolic syndrome in Chinese adolescents. Br J Nutr. 99(3): 565-70, 2008.

Liese AD, Mayer-Davis EJ, Haffner SM. Development of the multiple metabolic syndrome: an epidemiologic perspective. Epidemiol Rev. 20(2): 157-72, 1998.

Livingstone MB, Prentice AM, Coward WA, Ceesay SM, Strain JJ, McKenna PG, Nevin GB, Barker ME, Hickey RJ. Simultaneous measurement of free-living energy expenditure by the doubly labeled water method and heart-rate monitoring. Am J Clin Nutr. 52(1): 59-65, 1990.

Lobstein T, Baur L, Uauy R; IASO International Obesity TaskForce. Obesity in children and young people: a crisis in public health. Obes Rev. 5 Suppl 1: 4-104, 2004.

Lockner DW, Heyward VH, Baumgartner RN, Jenkins KA. Comparison of air-displacement plethysmography, hydrodensitometry, and dual X-ray absorptiometry for assessing body composition of children 10 to 18 years of age. Ann N Y Acad Sci. 904: 72-8, 2000.

Lohman TG. Applicability of body composition techniques and constants for children and youths. Exerc Sport Sci Rev. 14: 325-57, 1986.

Loube DI, Loube AA, Mitler MM. Weight loss for obstructive sleep apnea: the optimal therapy for obese patients. J Am Diet Assoc. 94(11): 1291-5, 1994.

Maffeis C, Zaffanello M, Pinelli L, Schutz Y. Total energy expenditure and patterns of activity in 8-10-year-old obese and nonobese children. J Pediatr Gastroenterol Nutr. 23(3): 256-61, 1996 Oct.

Magi L, Stramenga C, Morosini P; Gruppo di Studio SIMAP. [Prevalence of the metabolic syndrome among Italian adults. Findings from the SIMAP study] Recenti Prog Med. 96(6): 280-3, 2005.

Małecka-Tendera E, Koehler B, Ramos A, Dobrowolska-Wiciak B, Drzewiecka B. [Effect of marked obesity on the emotional status of children] Wiad Lek. 42(4): 234-8, 1989.

Malik M and Bakir A. Prevalence of overweight and obesity among children in the United Arab Emirates. Obes Rev. 8(1): 15-20, 2007.

Malina RM. Variation in body composition associated with sex and ethnicity. In: Heymsfield SB, Lohman TG, Wang Z, Going S, eds. Human Body Composition. 2nd ed. Champaign, IL: Human Kinetics: 271-298; Chapter 18, 2005.

Manios Y, Kondaki K, Kourlaba G, Grammatikaki E, Birbilis M, Ioannou E Television viewing and food habits in toddlers and preschoolers in Greece: the GENESIS study. Eur J Pediatr. 168(7): 801-8, 2009.

Marks GC, Habicht JP, Mueller WH. Reliability, dependability, and precision of anthropometric measurements. The Second National Health and Nutrition Examination Survey 1976-1980. Am J Epidemiol. 130(3): 578-87, 1989.

Matthew CE. Calibration of accelerometer output for adults. Med Sci Sports Exerc. 37(11 Suppl): S512-22, 2005.

Mazess RB, Barden HS, Bisek JP, Hanson J. Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. Am J Clin Nutr. 51(6): 1106-12, 1990.

Maziak W, Rastam S, Mzayek F, Ward KD, Eissenberg T, Keil U. Cardiovascular health among adults in Syria: a model from developing countries. Ann Epidemiol. 17(9): 713-20, 2007.

McConahy KL, Smiciklas-Wright H, Birch LL, Mitchell DC, Picciano MF. Food portions are positively related to energy intake and body weight in early childhood. J Pediatr. 140(3): 340-7, 2002.

McGuigan MR, Tatasciore M, Newton RU, Pettigrew S. Eight weeks of resistance training can significantly alter body composition in children who are overweight or obese. J Strength Cond Res. 23(1): 80-5, 2009.

Mei Z, Grummer-Strawn LM, Pietrobelli A, Goulding A, Goran MI, Dietz WH. Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. Am J Clin Nutr. 75(6): 978-85, 2002.

Meijer GA, Westerterp KR, Koper H, ten Hoor F. Assessment of energy expenditure by recording heart rate and body acceleration. Med Sci Sports Exerc. 21(3): 343-7, 1989.

Meisinger C, Döring A, Thorand B, Heier M, Löwel H. Body fat distribution and risk of type 2 diabetes in the general population: are there differences between men and women? The MONICA/KORA Augsburg cohort study. Am J Clin Nutr. 84(3): 483-9, 2006.

Melanson EL, Knoll JR, Bell ML, Donahoo WT, Hill JO, Nysse LJ, Lanningham-Foster L, Peters JC, Levine JA. Commercially available pedometers: considerations for accurate step counting. Prev Med. 39(2): 361-8, 2004.

Mendez MA, Monteiro CA, Popkin BM. Overweight exceeds underweight among women in most developing countries. Am J Clin Nutr. 81(3): 714-21, 2005.

Mihas C, Mariolis A, Manios Y, Naska A, Panagiotakos D, Arapaki A, Alevizos A, Mariolis-Sapsakos T, Tountas Y. Overweight/obesity and factors associated with body mass index during adolescence: the VYRONAS study. Acta Paediatr. 98(3): 495-500, 2009.

Moayeri H, Bidad K, Aghamohammadi A, Rabbani A, Anari S, Nazemi L, Gholami N, Zadhoush S, Hatmi ZN. Overweight and obesity and their associated factors in adolescents in Tehran, Iran, 2004-2005. Eur J Pediatr. 165(7): 489-93, 2006.

Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The spread of the obesity epidemic in the United States, 1991-1998. JAMA. 282(16): 1519-22. 1999.

Mokhtar N, Elati J, Chabir R, Bour A, Elkari K, Schlossman NP, Caballero B, Aguenaou H. Diet culture and obesity in northern Africa. J Nutr. 131(3): 887S-892S, 2001.

Molnár D, Varga P, Rubecz I, Hamar A, Mestyán J. Food-induced thermogenesis in obese children. Eur J Pediatr. 144(1): 27-31, 1985.

Monteiro CA, Conde WL, Popkin BM. Income-specific trends in obesity in Brazil: 1975-2003. Am J Public Health. 97(10): 1808-12, 2007.

Mossberg HO. 40-year follow-up of overweight children. Lancet. 2(8661): 491-3, 1989.

Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH. Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. N Engl J Med. 327(19): 1350-5, 1992.

Nair KS, Halliday D, Garrow JS. Thermic response to isoenergetic protein, carbohydrate or fat meals in lean and obese subjects. Clin Sci (Lond). 65(3): 307-12, 1983.

Nasreddine L, Mehio-Sibai A, Mrayati M, Adra N, Hwalla N. Adolescent obesity in Syria: prevalence and associated factors. , 2009.

Navder KP, He Q, Zhang X, He S, Gong L, Sun Y, Deckelbaum RJ, Thornton J, Gallagher D. Relationship between body mass index and adiposity in prepubertal children: ethnic and geographic comparisons between New York City and Jinan City (China). J Appl Physiol. 107(2): 488-93, 2009.

Neilson HK, Robson PJ, Friedenreich CM, Csizmadi I. Estimating activity energy expenditure: how valid are physical activity questionnaires? Am J Clin Nutr. 87(2): 279-91, 2008.

Newby PK, Muller D, Hallfrisch J, Andres R, Tucker KL. Food patterns measured by factor analysis and anthropometric changes in adults. Am J Clin Nutr. 80(2): 504-13, 2004.

Nieman DC, Austin MD, Chilcote SM, Benezra L. Validation of a new handheld device for measuring resting metabolic rate and oxygen consumption in children. Int J Sport Nutr Exerc Metab. 15(2): 186-94, 2005.

Ode JJ, Pivarnik JM, Reeves MJ, Knous JL. Body mass index as a predictor of percent fat in college athletes and nonathletes. Med Sci Sports Exerc. 39(3): 403-9, 2007.

Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. JAMA. 295(13): 1549-55, 2006.

Oğuz A, Temizhan A, Abaci A, Kozan O, Erol C, Ongen Z, Celik S. Obesity and abdominal obesity; an alarming challenge for cardio-metabolic risk in Turkish adults. Anadolu Kardiyol Derg. 8(6): 401-6, 2008.

Olaiz G, Rivera J, Shamah T, Rojas R, Villalpando S, Herna´ndez M, Sepu´ lveda J 2008 Encuesta Nacional de Salud y Nutricio´n, 2006. Available at: http://www.insp.mx/ensanut2006.pdf. Accessed on Dec 8, 2009.

Oner N, Vatansever U, Sari A, Ekuklu E, Güzel A, Karasaliho lu S, Boris NW. Prevalence of underweight, overweight and obesity in Turkish adolescents. Swiss Med Wkly. 134(35-36): 529-33, 2004.

Ozsahin AK, Gokcel A, Sezgin N, Akbaba M, Guvener N, Ozisik L, Karademir BM. Prevalence of the metabolic syndrome in a Turkish adult population. Diabetes Nutr Metab. 17(4): 230-4, 2004.

Pace N, 1995 EN. Studies on body composition. III. The body water and chemically combined nitrogen content in relation to fat content. *J Biol Chem*. 158: 685-691, 1995.

Patrick K, Norman GJ, Calfas KJ, Sallis JF, Zabinski MF, Rupp J, Cella J. Diet, physical activity, and sedentary behaviors as risk factors for overweight in adolescence. Arch Pediatr Adolesc Med. 158(4): 385-90, 2004.

Pereira MA, FitzerGerald SJ, Gregg EW, Joswiak ML, Ryan WJ, Suminski RR, Utter AC, Zmuda JM. A collection of Physical Activity Questionnaires for health-related research. Med Sci Sports Exerc. 29(6 Suppl): S1-205, 1997.

Pereira MA, Kartashov AI, Ebbeling CB, Van Horn L, Slattery ML, Jacobs DR Jr, Ludwig DS. Fast-food habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. Lancet. 365(9453): 36-42, 2005.

Pérez-Cueto FJ, Botti AB, Verbeke W. Prevalence of overweight in Bolivia: data on women and adolescents. Obes Rev. 10(4): 373-7, 2009.

Pietrobelli A, Faith MS, Allison DB, Gallagher D, Chiumello G, Heymsfield SB. Body mass index as a measure of adiposity among children and adolescents: a validation study. J Pediatr. 132(2): 204-10, 1998.

Pinhas-Hamiel O, Dolan LM, Daniels SR, Standiford D, Khoury PR, Zeitler P. Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. J Pediatr. 128(5 Pt 1): 608-15, 1996.

Pintauro SJ, Nagy TR, Duthie CM, Goran MI. Cross-calibration of fat and lean measurements by dual-energy X-ray absorptiometry to pig carcass analysis in the pediatric body weight range. Am J Clin Nutr. 63(3): 293-8, 1996.

Plasqui G and Westerterp KR. Physical activity assessment with accelerometers: an evaluation against doubly labeled water. Obesity (Silver Spring). 15(10): 2371-9, 2007.

Pongchaiyakul C, Kosulwat V, Rojroongwasinkul N, Charoenkiatkul S, Thepsuthammarat K, Laopaiboon M, Nguyen TV, Rajatanavin R. Prediction of percentage body fat in rural thai population using simple anthropometric measurements. Obes Res. 13(4): 729-38, 2005.

Poskitt EM. Defining childhood obesity: the relative body mass index (BMI). European Childhood Obesity group. Acta Paediatr. 84(8): 961-3, 1995.

Prentice AM and Jebb SA. Fast foods, energy density and obesity: a possible mechanistic link. Obes Rev. 4(4): 187-94, 2003.

Prentice AM and Jebb SA. Obesity in Britain: gluttony or sloth? BMJ. 311(7002): 437-9, 1995.

Prentice AM. Regional case studies--Africa. Nestle Nutr Workshop Ser Pediatr Program. 63: 33-41; discussion 41-6, 259-68, 2009.

Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. Int J Behav Nutr Phys Act. 5: 56, 2008.

Ravussin E, Valencia ME, Esparza J, Bennett PH, Schulz LO. Effects of a traditional lifestyle on obesity in Pima Indians. Diabetes Care. 17(9): 1067-74, 1994.

Reeder BA, Angel A, Ledoux M, Rabkin SW, Young TK, Sweet LE. Obesity and its relation to cardiovascular disease risk factors in Canadian adults. Canadian Heart Health Surveys Research Group. CMAJ. 146(11): 2009-19, 1992.

Reis JP, Dubose KD, Ainsworth BE, Macera CA, Yore MM. Reliability and validity of the occupational physical activity questionnaire. Med Sci Sports Exerc. 37(12): 2075-83, 2005.

Rey-López JP, Vicente-Rodríguez G, Biosca M, Moreno LA. Sedentary behaviour and obesity development in children and adolescents. Nutr Metab Cardiovasc Dis. 18(3): 242-51, 2008.

Reynolds K, Gu D, Whelton PK, Wu X, Duan X, Mo J, He J; InterASIA Collaborative Group. Prevalence and risk factors of overweight and obesity in China. Obesity (Silver Spring). 15(1): 10-8, 2007.

Reynolds KD, Killen JD, Bryson SW, Maron DJ, Taylor CB, Maccoby N, Farquhar JW. Psychosocial predictors of physical activity in adolescents. Prev Med. 19(5): 541-51, 1990.

Richardson MT, Leon AS, Jacobs DR Jr, Ainsworth BE, Serfass R. Comprehensive evaluation of the Minnesota Leisure Time Physical Activity Questionnaire. J Clin Epidemiol. 47(3): 271-81, 1994.

Rimm EB, Stampfer MJ, Colditz GA, Chute CG, Litin LB, Willett WC. Validity of self-reported waist and hip circumferences in men and women. Epidemiology. 1(6): 466-73, 1990.

Robinson TN, Killen JD, Kraemer HC, Wilson DM, Matheson DM, Haskell WL, Pruitt LA, Powell TM, Owens AS, Thompson NS, Flint-Moore NM, Davis GJ, Emig KA, Brown RT, Rochon J, Green S, Varady A. Dance and reducing television viewing to prevent weight gain in African-American girls: the Stanford GEMS pilot study. Ethn Dis. 13(1 Suppl 1): S65-77, 2003.

Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled trial. JAMA. 282(16): 1561-7, 1999.

Rolland-Cachera MF, Deheeger M, Guilloud-Bataille M, Avons P, Patois E, Sempé M. Tracking the development of adiposity from one month of age to adulthood. Ann Hum Biol. 14(3): 219-29, 1987.

Rolland-Cachera MF, Sempé M, Guilloud-Bataille M, Patois E, Péquignot-Guggenbuhl F, Fautrad V. Adiposity indices in children. Am J Clin Nutr. 36(1): 178-84, 1982.

Rosenbloom AL, Joe JR, Young RS, Winter WE. Emerging epidemic of type 2 diabetes in youth. Diabetes Care. 22(2): 345-54, 1999.

Ross R and Janssen I. Computer tomography and magnetic resonance imaging. In: Heymsfield SB, Lohman TG, Wang Z, Going S, eds. *Human Body Composition*. 2n ed. Champaign, IL: Human Kinetics; 89-108; Chapter 7, 2005.

Rowlands AV. Accelerometer assessment of physical activity in children: an update. Pediatr Exerc Sci. 19(3): 252-66, 2007.

Rush E, Plank L, Chandu V, et al. Body size, body composition, and fat distribution: a comparison of young New Zealand men of European, Pacific Island, and Asian Indian ethnicities. N Z Med J. 117(1207), 2004.

SADHS, South Africa Demographic Health Survey. Preliminary Report, Medical Research Council and Department of Health, 2003. Available at: http://70.84.171.10/~etools/doh/sadhs/chapter13.pdf. Accessed Dec 10, 2009.

Sallis JF, Haskell WL, Wood PD, Fortmann SP, Rogers T, Blair SN, Paffenbarger RS Jr. Physical activity assessment methodology in the Five-City Project. Am J Epidemiol. 121(1): 91-106, 1985.

Sallis JF, Simons-Morton BG, Stone EJ, Corbin CB, Epstein LH, Faucette N, Iannotti RJ, Killen JD, Klesges RC, Petray CK. Determinants of physical activity and interventions in youth. Med Sci Sports Exerc. 24(6 Suppl): S248-57, 1992.

Sallis JF. Epidemiology of physical activity and fitness in children and adolescents. Crit Rev Food Sci Nutr. 33(4-5): 403-8, 1993.

Samdal O, Tynjälä J, Roberts C, Sallis JF, Villberg J, Wold B. Trends in vigorous physical activity and TV watching of adolescents from 1986 to 2002 in seven European Countries. Eur J Public Health. 17(3): 242-8, 2007.

Sardinha LB, Going SB, Teixeira PJ, Lohman TG. Receiver operating characteristic analysis of body mass index, triceps skinfold thickness, and arm girth for obesity screening in children and adolescents. Am J Clin Nutr. 70: 1090-95, 1999.

Saris WH. Habitual physical activity in children: methodology and findings in health and disease. Med Sci Sports Exerc. 18(3): 253-63, 1986.

Schneider PL, Crouter SE, Bassett DR. Pedometer measures of free-living physical activity: comparison of 13 models. Med Sci Sports Exerc. 36(2): 331-5, 2004.

Schoeller DA and Fjeld CR. Human energy metabolism: what have we learned from the doubly labeled water method? Annu Rev Nutr. 11: 355-73, 1991.

Schoeller DA, Tylavsky FA, Baer DJ, Chumlea WC, Earthman CP, Fuerst T, Harris TB, Heymsfield SB, Horlick M, Lohman TG, Lukaski HC, Shepherd J, Siervogel RM, Borrud LG. QDR 4500A dual-energy X-ray absorptiometer underestimates fat mass in comparison with criterion methods in adults. Am J Clin Nutr. 81(5): 1018-25, 2005.

Schoeller DA. Chapter 3. Hydrometry. In: Heymsfield SB, Lohman TG, Wang Z, Going S, eds. Human Body Composition. 2nd ed. Champaign, IL: Human Kinetics; 2005.

Schoeller DA. Measurement of energy expenditure in free-living humans by using doubly labeled water. J Nutr. 118(11): 1278-89, 1988.

Schröder H, Fïto M, Covas MI; REGICOR investigators. Association of fast food consumption with energy intake, diet quality, body mass index and the risk of obesity in a representative Mediterranean population. Br J Nutr. 98(6): 1274-80, 2007.

Seabra AF, Mendonça DM, Thomis MA, Peters TJ, Maia JA. Associations between sport participation, demographic and socio-cultural factors in Portuguese children and adolescents. Eur J Public Health. 18(1):25-30, 2008.

Segal KR. Use of bioelectrical impedance analysis measurements as an evaluation for participating in sports. Am J Clin Nutr. 64(3 Suppl): 469S-471S, 1996.

Seidell JC, Bakker CJ, van der Kooy K. Imaging techniques for measuring adipose-tissue distribution--a comparison between computed tomography and 1.5-T magnetic resonance. Am J Clin Nutr. 51(6): 953-7, 1990.

Sengupta AK, Sarkar DN, Mukhopadhyay S, Goswami DC. Relationship between pulse rate and energy expenditure during graded work at different temperatures. Ergonomics. 22(11): 1207-15, 1979.

Serra Majem L, Ribas Barba L, Aranceta Bartrina J, Pérez Rodrigo C, Saavedra Santana P, Peña Quintana L. [Childhood and adolescent obesity in Spain. Results of the enKid study (1998-2000)] Med Clin (Barc). 121(19): 725-32, 2003.

Sharp TA, Reed GW, Sun M, Abumrad NN, Hill JO. Relationship between aerobic fitness level and daily energy expenditure in weight-stable humans. Am J Physiol. 263(1 Pt 1): E121-8, 1992.

Shepherd EF, Toloza E, McClung CD, Schmalzried TP. Step activity monitor: increased accuracy in quantifying ambulatory activity. J Orthop Res. 17(5) :703-8, 1999.

Shields M. Measured obesity: overweight Canadian children and adolescents. In: Nutrition: findings from the Canadian Community Health Survey; issue 1; 2005(cat no 82-620-MWE2005001). Available at: www.statcan.ca/english/research/82-620-MIE/2005001/pdf/cobesity.pdf (accessed 2009 Dec 6).

Sibai AM, Hwalla N, Adra N, Rahal B. Prevalence and covariates of obesity in Lebanon: findings from the first epidemiological study. Obes Res. 11(11): 1353-61, 2003 a.

Sibai, A. M., Kanaan, N., Chaaya, M., Rahal, B., Abdullah, A., Sibai, T. Ethnic differences in weight loss behavior among secondary school students in Beirut: the role of weight perception. Soz Praventivmed. 48: 234–241, 2003 b.

Sirard JR and Pate RR. Physical activity assessment in children and adolescents. Sports Med. 31(6): 439-54, 2001.

Siri WE. Body composition from fluid spaces and density: analysis of methods. 1961. Nutrition. 9(5): 480-91; discussion 480, 492, 1993.

Skelton JA, Cook SR, Auinger P, Klein JD, Barlow SE. Prevalence and trends of severe obesity among US children and adolescents. Acad Pediatr. 2009 Sep-Oct;9(5):322-9. Epub 2009 Jun 27.

Smith JD and **Schroeder CA**. Assessing pedometer accuracy while walking, skipping, galloping, sliding, and hopping. J Strength Cond Res. 22(1): 276-82, 2008.

Srinivasan SR, Bao W, Wattigney WA, Berenson GS. Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: the Bogalusa Heart Study. Metabolism. 45(2): 235-40, 1996.

Srinivasan SR, Frontini MG, Berenson GS; Bogalusa Heart Study. Longitudinal changes in risk variables of insulin resistance syndrome from childhood to young adulthood in offspring of parents with type 2 diabetes: the Bogalusa Heart Study. Metabolism. 52(4): 443-50; discussion 451-3, 2003.

Stamler R, Stamler J, Riedlinger WF, Algera G, Roberts RH. Weight and blood pressure. Findings in hypertension screening of 1 million Americans. JAMA. 240(15): 1607-10, 1978.

Stampfer MJ, Maclure KM, Colditz GA, Manson JE, Willett WC. Risk of symptomatic gallstones in women with severe obesity. Am J Clin Nutr. 55(3): 652-8, 1992.

Starck G, Lönn L, Cederblad A, Alpsten M, Sjöström L, Ekholm S. Dose reduction for body composition measurements with CT. Appl Radiat Isot. 49(5-6): 561-3, 1998.

Starck G, Lönn L, Cederblad A, Forssell-Aronsson E, Sjöström L, Alpsten M. A method to obtain the same levels of CT image noise for patients of various sizes, to minimize radiation dose. Br J Radiol. 75(890): 140-50, 2002.

Starling RD, Matthews DE, Ades PA, Poehlman ET. Assessment of physical activity in older individuals: a doubly labeled water study. J Appl Physiol. 86(6): 2090-6, 1999.

Steinberger J, Jacobs DR, Raatz S, Moran A, Hong CP, Sinaiko AR. Comparison of body fatness measurements by BMI and skinfolds vs dual energy X-ray absorptiometry and their relation to cardiovascular risk factors in adolescents. Int J Obes (Lond). 29(11): 1346-52, 2005.

Stevens J, Cai J, Evenson KR, Thomas R. Fitness and fatness as predictors of mortality from all causes and from cardiovascular disease in men and women in the lipid research clinics study. Am J Epidemiol. 156(9): 832-41, 2002.

Strath SJ, Bassett DR Jr, Swartz AM, Thompson DL. Simultaneous heart rate-motion sensor technique to estimate energy expenditure. Med Sci Sports Exerc. 33(12): 2118-23, 2001.

Strath SJ, Bassett DR Jr, Thompson DL, Swartz AM. Validity of the simultaneous heart rate-motion sensor technique for measuring energy expenditure. Med Sci Sports Exerc. 34(5): 888-94, 2002.

Strauss CC, Smith K, Frame C, Forehand R. Personal and interpersonal characteristics associated with childhood obesity. J Pediatr Psychol. 10(3): 337-43, 1985.

Stunkard AJ, Harris JR, Pedersen NL, McClearn GE. The body-mass index of twins who have been reared apart. N Engl J Med. 322(21): 1483-7, 1990.

Sun G, French CR, Martin GR, Younghusband B, Green RC, Xie YG, Mathews M, Barron JR, Fitzpatrick DG, Gulliver W, Zhang H. Comparison of multifrequency bioelectrical impedance analysis with dual-energy X-ray absorptiometry for assessment of percentage body fat in a large, healthy population. Am J Clin Nutr. 81(1): 74-8, 2005.

Sun H, Tang H, Jiang S, Zeng L, Chen EQ, Zhou TY, Wang YJ. Gender and metabolic differences of gallstone diseases. World J Gastroenterol. 15(15): 1886-91, 2009.

Svendsen OL, Haarbo J, Hassager C, Christiansen C. Accuracy of measurements of body composition by dual-energy x-ray absorptiometry in vivo. Am J Clin Nutr. 57(5): 605-8, 1993.

Swaminathan R, King RF, Holmfield J, Siwek RA, Baker M, Wales JK. Thermic effect of feeding carbohydrate, fat, protein and mixed meal in lean and obese subjects. Am J Clin Nutr. 42(2): 177-81, 1985.

Swartz AM, Bassett DR Jr, Moore JB, Thompson DL, Strath SJ. Effects of body mass index on the accuracy of an electronic pedometer. Int J Sports Med. 24(8): 588-92, 2003.

Tataranni PA and Ravussin E. Use of dual-energy X-ray absorptiometry in obese individuals. Am J Clin Nutr. 62(4): 730-4, 1995.

Taylor ED, Theim KR, Mirch MC, Ghorbani S, Tanofsky-Kraff M, Adler-Wailes DC, Brady S, Reynolds JC, Calis KA, Yanovski JA. Orthopedic complications of overweight in children and adolescents. Pediatrics. 117(6): 2167-74, 2006.

Taylor RW, Jones IE, Williams SM, Goulding A. Body fat percentages measured by dual-energy X-ray Absorptiometry corresponding to recently recommended body mass index cutoffs for overweight and obesity in children and adolescents aged 3–18 y. Am J Clin Nutr. 76: 1416–21, 2002.

Testa MA and Simonson DC. Assesment of quality-of-life outcomes. N Engl J Med. 334(13): 835-40, 1996.

Thomas SR, Kalkwarf HJ, Buckley DD, Heubi JE. Effective dose of dual-energy X-ray absorptiometry scans in children as a function of age. J Clin Densitom. 8(4): 415-22, 2005.

Thomasset MA. Bioelectric properties of tissue. Impedance measurement in clinical medicine. Significance of curves obtained. Lyon Med. 94: 107-18, 1962.

Thompson D and Wolf AM. The medical-care cost burden of obesity. Obes Rev. 2(3): 189-97, 2001.

Tothill P, Avenell A, Love J, Reid DM. Comparisons between Hologic, Lunar and Norland dual-energy X-ray absorptiometers and other techniques used for whole-body soft tissue measurements. Eur J Clin Nutr. 48(11): 781-94, 1994 a.

Tothill P, Avenell A, Reid DM. Precision and accuracy of measurements of whole-body bone mineral: comparisons between Hologic, Lunar and Norland dual-energy X-ray absorptiometers. Br J Radiol. 67(804): 1210-7, 1994 b.

Trabulsi J, Schoeller DA. Evaluation of dietary assessment instruments against doubly labeled water, a biomarker of habitual energy intake. Am J Physiol Endocrinol Metab. 281(5): E891-9, 2001.

Tremblay MS and Willms JD. Secular trends in the body mass index of Canadian children. CMAJ. 163(11): 1429-33, 2000.

Treuth MS, Figueroa-Colon R, Hunter GR, Weinsier RL, Butte NF, Goran MI. Energy expenditure and physical fitness in overweight vs non-overweight prepubertal girls. Int J Obes Relat Metab Disord. 22(5): 440-7, 1998.

Troiano RP and Flegal KM. Overweight prevalence among youth in the United States: why so many different numbers? Int J Obes Relat Metab Disord. 23 Suppl 2: S22-7, 1999.

Tsiros MD, Olds T, Buckley JD, Grimshaw P, Brennan L, Walkley J, Hills AP, Howe PR, Coates AM. Health-related quality of life in obese children and adolescents. Int J Obes (Lond). 33(4): 387-400, 2009.

Tudor-Locke C, Ainsworth BE, Adair LS, Du S, Lee N, Popkin BM. Cross-sectional comparison of physical activity and inactivity patterns in Chinese and Filipino youth. Child Care Health Dev. 33(1): 59-66, 2007.

Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, Keinänen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, Salminen V, Uusitupa M; Finnish Diabetes Prevention Study Group. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N Engl J Med. 344(18):1343-50, 2001.

Tzotzas T, Kapantais E, Tziomalos K, Ioannidis I, Mortoglou A, Bakatselos S, Kaklamanou M, Lanaras L, Kaklamanos I. Epidemiological survey for the prevalence of overweight and abdominal obesity in Greek adolescents. Obesity (Silver Spring). 16(7):1718-22, 2008.

U.S. Department of Health and Human Services. The Surgeon General's Call To Action To Prevent and Decrease Overweight and Obesity 2001. Available at: http://www.surgeongeneral.gov/library. Accessed on December 20, 2009.

Utter J, Scragg R, Schaaf D. Associations between television viewing and consumption of commonly advertised foods among New Zealand children and young adolescents. Public Health Nutr. 9(5): 606-12, 2006.

Vague J. The degree of masculine differentiation of obesities: a factor determining predisposition to diabetes, atherosclerosis, gout, and uric calculous disease. Am J Clin Nutr. 4(1): 20-34, 1956.

Valdez R, Greenlund KJ, Wattigney WA, Bao W, Berenson GS. Use of weight-for-height indices in children to predict adult overweight: the Bogalusa Heart Study. Int J Obes Relat Metab Disord. 20(8): 715-21, 1996.

van der Sande MA, Ceesay SM, Milligan PJ, Nyan OA, Banya WA, Prentice A, McAdam KP, Walraven GE. Obesity and undernutrition and cardiovascular risk factors in rural and urban Gambian communities. Am J Public Health. 91 (10): 1641-4, 2001.

Varni JW, Burwinkle TM, Seid M, Skarr D. The PedsQL 4.0 as a pediatric population health measure: feasibility, reliability, and validity. Ambul Pediatr. 3(6): 329-41, 2003.

Varni JW, Seid M, Rode CA. The PedsQL: measurement model for the pediatric quality of life inventory. Med Care. 37(2): 126-39, 1999.

Vazquez G, Duval S, Jacobs DR Jr, Silventoinen K. Comparison of body mass index, waist circumference, and waist/hip ratio in predicting incident diabetes: a meta-analysis. Epidemiol Rev. 29: 115-28, 2007.

Visser GH, Boon PE, Meijer HA. Validation of the doubly labeled water method in Japanese Quail Coturnix c. japonica chicks: is there an effect of growth rate? J Comp Physiol B. 170(5-6): 365-72, 2000.

Vogler GP, Sørensen TI, Stunkard AJ, Srinivasan MR, Rao DC. Influences of genes and shared family environment on adult body mass index assessed in an adoption study by a comprehensive path model. Int J Obes Relat Metab Disord. 19(1): 40-5, 1995.

Wabitsch M, Hauner H, Hertrampf M, Muche R, Hay B, Mayer H, Kratzer W, Debatin KM, Heinze E. Type II diabetes mellitus and impaired glucose regulation in Caucasian children and adolescents with obesity living in Germany. Int J Obes Relat Metab Disord. 28(2): 307-13, 2004.

Wagner DR and Heyward VH. Measures of body composition in blacks and whites: a comparative review. Am J Clin Nutr. 71(6): 1392-402, 2000.

Wang Y, Monteiro C, Popkin BM. Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. Am J Clin Nutr. 75(6): 971-7, 2002.

Wang Y, Rimm EB, Stampfer MJ, Willett WC, Hu FB. Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men. Am J Clin Nutr. 81(3): 555-63, 2005.

Ward LC, Dyer JM, Byrne NM, Sharpe KK, Hills AP. Validation of a three-frequency bio-impedance spectroscopic method for body composition analysis. Nutrition. 23(9): 657-64, 2007.

Wareham NJ and Rennie KL. The assessment of physical activity in individuals and populations: why try to be more precise about how physical activity is assessed? Int J Obes Relat Metab Disord. 22 Suppl 2: S30-8, 1998.

Washburn R, Chin MK, Montoye HJ. Accuracy of pedometer in walking and running. Res Q Exerc Sport. 51(4): 695-702, 1980.

Watts K, Naylor LH, Davis EA, Jones TW, Beeson B, Bettenay F, Siafarikas A, Bell L, Ackland T, Green DJ. Do skinfolds accurately assess changes in body fat in obese children and adolescents? Med Sci Sports Exerc. 38(3): 439-44, 2006.

Webb P. The measurement of energy expenditure. J Nutr. 121(11): 1897-901, 1991.

Wen CP, David Cheng TY, Tsai SP, Chan HT, Hsu HL, Hsu CC, Eriksen MP. Are Asians at greater mortality risks for being overweight than Caucasians? Redefining obesity for Asians. Public Health Nutr. 12(4): 497-506, 2009.

Weststrate JA and Deurenberg P. Body composition in children: proposal for a method for calculating body fat percentage from total body density or skinfold-thickness measurements. Am J Clin Nutr 1989; 50: 1104–15.

Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med. 337(13): 869-73, 1997.

Whitlock G, Lewington S, Sherliker P, Clarke R, Emberson J, Halsey J, Qizilbash N, Collins R, Peto R. Prospective Studies Collaboration. Mortality in 900 000 adults: collaborative analyses of 57 prospective studies. Lancet. 373(9669): 1083-96, 2009.

Wickramasinghe VP, Cleghorn GJ, Edmiston KA, Murphy AJ, Abbott RA, Davies PS. Validity of BMI as a measure of obesity in Australian white Caucasian and Australian Sri Lankan children. Ann Hum Biol. 32(1): 60-71, 2005.

Wiegand S, Maikowski U, Blankenstein O, Biebermann H, Tarnow P, Grüters A. Type 2 diabetes and impaired glucose tolerance in European children and adolescents with obesity -- a problem that is no longer restricted to minority groups. Eur J Endocrinol. 151(2): 199-206, 2004.

Wolf AM and Colditz GA. Current estimates of the economic cost of obesity in the United States. Obes Res. 6(2): 97-106, 1998.

Woolf AD, Breedveld F, Kvien TK. Controlling the obesity epidemic is important for maintaining musculoskeletal health. Ann Rheum Dis. 65(11): 1401-2, 2006.

World Health Organization, 1998. Obesity: Preventing and Managing the Global Epidemic. Report of the WHO Consultation of Obesity. Geneva. Available at:http://whqlibdoc.who.int/hq/1998/WHO_NUT_NCD_98.1_(p1-158).pdf. Accessed on November 14, 2009.

World Health Organization, 2006. Media Center. Fact Sheet No: 311. Available at: http://www.who.int/mediacentre/factsheets/fs311/en/. Accessed on December 15, 2009.

World Health Organization. Health System and Performance in Lebanon. Beirut, Lebanon: Ministry of Public Health; 2003.

World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser. 894: i-xii, 1-253, 2000.

World Health Organization. Physical Status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser; 854: 1-452, 1995.

Wrotniak BH, Epstein LH, Paluch RA, Roemmich JN. Parent weight change as a predictor of child weight change in family-based behavioral obesity treatment. Arch Pediatr Adolesc Med. 158(4): 342-7, 2004.

Yang X, Telama R, Hirvensalo M, Mattsson N, Viikari JS, Raitakari OT. The longitudinal effects of physical activity history on metabolic syndrome. Med Sci Sports Exerc. 40(8): 1424-31. 2008.

Yoshiike N, Kaneda F, Takimoto H. Epidemiology of obesity and public health strategies for its control in Japan. Asia Pac J Clin Nutr. 11 Suppl 8: S727-31, 2002.

Zemel. The role of dairy foods in weight management. J Am Coll Nutr. 24(6 Suppl): 537S-46S, 2005.

Zhao W, Zhai Y, Hu J, Wang J, Yang Z, Kong L, Chen C. Economic burden of obesity-related chronic diseases in Mainland China. Obes Rev. 9 Suppl 1: 62-7, 2008.

PART 3: APPENDIX

APPENDIX A: General Questionnaire

N° ________

Bonjour, et merci d'etre la aujourd'hui pour repondre a ce questionnaire qui va servir a une etude epidemiologique sur l'adolescent libanais. Pour que nos resultats soient fiables, nous vous demandons de prendre votre temps pour repondre aux differentes questions du mieux que vous le pouvez.
Ceci n'est pas un test : Il n'y a pas de reponses fausses ou correctes. Il faut que vos reponses correspondent a votre mode de vie.
Ce questionnaire est **totalement anonyme,** personne de votre entourage ou de vos ami(e)s n'y aura acces. Le numero qui figure em haut du questionnaire assure votre anonymat. Ceci garanti votre anonymat memes pour les membre de notre equipe qui traiteront les resultats.

DONNEES GENERALES

- Adresse (juste mentionner la ville ou le village ou vous vivez) : ______________________
- Age : ____ ans
- Sexe : ___
- Classe : _______
- Si possible, quelle etait votre moyennes generale de l'anne derniere (/20 ou /100)

DONNEES ANTROPOMETRIQUES

- Taille : ______
- Poids : ______

DONNEES PHYSIOLOGIQUES

- Est.ce que vous etes pubere ? Oui Non
    - Est-ce que vous vous raser ? Oui Non
    - Est-ce que vous avez des poils sous les bras ? Oui Non

- Pouvez vous <u>si possible</u> indiquer votre poids aux ages suivants (en utilisant votre carnet de sante ou avec l'aide de vos parents) ?
    - A la naissance : _____Kg
    - A 5 ans : _____Kg
    - A 10 ans : _____Kg
    - Avez-vous remarque une prise de poids avec la puberte ? Oui Non
    - Si oui pouvez-vous estimer de combien de kilo ? _____Kg

SANTE

- Avez vous une maladie chronique liee a l'obesite (diabetes, cholesterol...) : Oui Non
    - Si oui, laquelle : _______________

SITUATION FAMILIALE

- Etes-vous fils unique : Oui Non
- Etes-vous l'ainee de la famille : Oui Non
    - Si non quelle est votre place (ex : 2/3 si vous etes le deuxieme sur trois enfants) :___/___
- Est-ce qu'un de vos freres ou soeurs (si vous en avez) a un exces de poids ? Oui Non

VOS HABITUDES

- Avez-vous l'habitude de prendre un petit-dejeuner
  Oui, toujours   Oui, de temps en temps   Non, jamais

- A votre avis, est-ce que votre alimentation est equilibree ? Oui Non

- Avez-vous a la maison :
  - Une television : Oui Non
    - Combien de temps **par jour** passez-vous en moyenne a regarder la television
      - Les jours d'ecole :___h
      - Les jour de vacances et le week-end :___h

    - Avez-vous une television dans votre chambre ? oui non

  - Un ordinateur : Oui Non
    - Combien de temps **par jour** passez-vous en moyenne devant l'ordinateur
      - Les jours d'ecole :___h
      - Les jour de vacances et le week-end :___h

  - Des jeux video : Oui Non
    - Combien de temps **par jour** passez-vous en moyenne a jouer
      - Les jours d'ecole :___h
      - Les jour de vacances et le week-end :___h

- Combien de temps **par jour** passez-vous assis (lecture, cours de classe, bavardage entre ami(e)s) ? ____h

- En moyenne combien d'heure dormez-vous par nuit ? ____h
  - Jour avec ecole le landemain : ____h par nuit
  - Jour sans ecole le landemain : ____h par nuit

- Sieste (nombre d'heure par semaine) : ____h par semaine

ACTIVITES

- Participez vous aux cours d'education physique et sportive (EPS) a l'ecole ? Oui Non
  - Si oui combien d'heure par semaines faites vous ? ____h

- Participez-vous a une activite sportive reguliere hors ou dans l'ecole ? Oui Non
  - Si oui laquelle ? ____________
  - Est-ce une activite de loisir ou de competition ? Loisir Competition

- Allez vous regulierement a la piscine, a la patinoire ? Oui Non

- Comment venez-vous a l'ecole :
  A pieds   En velo   En voiture avec vos parents   En bus

- Combien de voiture avez-vous a la maison ?____   avez-vous une pour vous ? Oui
  Non

QUESTIONS A PROPOS DE VOS PARENTS

- Votre maire vous a t-elle allaite ? Oui Non
- Si oui pendant combien de temps ? ______ mois

- Donnes concernant vos parents :

	Pere	Mere
Ages (ans)		
Taille (m)		
Poids (Kg)		
Metier		
Salaire mensuel (si possible)		

- Le niveau d'etude de vos parents

Pere : Diplome inferieur au Bac Bac Bac +3 (licence) Bac +5 (master ou plus)
Mere : Diplome inferieur au Bac Bac Bac +3 (licence) Bac +5 (master ou plus)

- Vos parents ont-ils une maladie liee a l'obesite ? Oui Non

  - Si oui, laquelle (diabete, cholesterol, hypertension arterielle, maladie cardiaque)... ? ________________

- Pendant votre enfance (aux environs de 5 ans) vous etiez plutot : (demander aux parents)

Peu actif Moyennement actif Tres actif

APPENDIX B : Physical Activity Questionnaire

1. **Sport:** A chaque fois vous preciserez, **les nombre de séance par semaine, le temps passe et l'intensite** (legere/moyenne/haute en se referant a l'essoufflement, la seur...)

» » Exemple : 2 fois 1h30 d'education physique par semaine a intensite moyenne
5 fois 15 minutes de foot a la recreation a intensite elevee

- **A l'ecole :**

		Nombre de fois / semaine	Nombre d'heure ou de minutes / seance	Intensite (legere/moyenne/haute)
Education physique et sportive				
Recreation				
Autre				

- **En dehors de l'ecole :**

➢ **Club**

Sport		Nombre de fois / semaine	Nombre d'heure ou de minutes / seance	Intensite (legere/moyenne/haute)

Competition : Oui Non

➢ **A la maison**

		Sport	Nombre de fois / semaine	Nombre d'heure ou de minutes / seance	Intensite (legere/moyenne/haute)
Dans la semaine					
Week-end					

Renforcement musculaire (minutes par semaine)
Etirement, assouplissement (minutes par semaine)

Appendix C: Pediatric Quality of Life Questionnaire

Au cours MOIS Dernier, les choses suivantes ont-elles ete un **probleme pour toi**

MA SANTE ET MES ACTIVITES (problemes avec)	**Jamais**	**Presque jamais**	**Parfois**	**Souvent**	**Presque toujours**
1- J'ai des difficultes a marcher plus loin que le coin de la rue	0	1	2	3	4
2- J'ai des difficultes a courir	0	1	2	3	4
3- J'ai des difficultes a faire du sport ou de l'exercice	0	1	2	3	4
4- J'ai des difficultes a soulever un objet lourd	0	1	2	3	4
5- J'ai des difficultes a prendre un bain ou une douche tout(e) seul(e)	0	1	2	3	4
6- J'ai des difficultes a aider dans la maison	0	1	2	3	4
7- Je ressens des souleur	0	1	2	3	4
9- Je manque d'energie	0	1	2	3	4

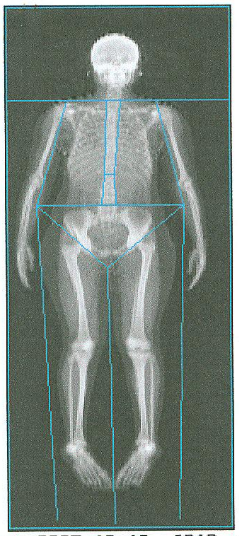
MES EMOTIONS (problemes avec...)	**Jamais**	**Presque jamais**	**Parfois**	**Souvent**	**Presque toujours**
1- J'ai peur	0	1	2	3	4
2- Je me sens triste ou deprime(e)	0	1	2	3	4
3- Je me sens en colere ou enerve(e)	0	1	2	3	4
4- J'ai du mal a dormir	0	1	2	3	4
5- Je m'inquiete de ce qui va m'arriver	0	1	2	3	4

MES RELATIONS AVEC LES AUTRES ADOLESCENTS (problemes avec...)	**Jamais**	**Presque jamais**	**Parfois**	**Souvent**	**Presque toujours**
1- J'ai du mal a m'entendre avec les autres	0	1	2	3	4
2- Les autres ne veulent pas etre amis avec moi	0	1	2	3	4
3- Les autres se moquent de moi	0	1	2	3	4
4- Je ne peux pas faire certaines choses que les autres jeunes de mon age peuvent faire	0	1	2	3	4
5- J'ai du mal a suivre les autres	0	1	2	3	4

MES RELATIONS AVEC LES AUTRES ADOLESCENTS (problemes avec...)	**Jamais**	**Presque jamais**	**Parfois**	**Souvent**	**Presque toujours**
1- J'ai du mal a m'entendre avec les autres	0	1	2	3	4
2- Les autres ne veulent pas etre amis avec moi	0	1	2	3	4
3- Les autres se moquent de moi	0	1	2	3	4
4- Je ne peux pas faire certaines choses que les autres jeunes de mon age peuvent faire	0	1	2	3	4
5- J'ai du mal a suivre les autres	0	1	2	3	4

Appendix D: DXA whole-body scans

HOTEL-DIEU DE FRANCE BEYROUTH



o03.Dec.2005 10:13 [318 x 150]
Hologic QDR-4500W (S/N 48937)
Whole Body V8.26a:5

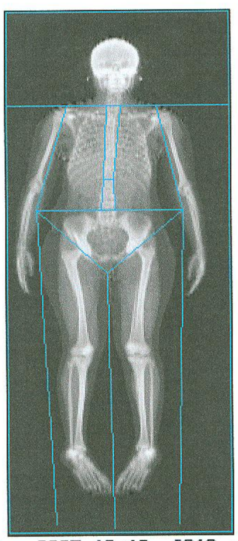
A12030504 Sat 03.Dec.2005 10:01
Name:
Comment: balamana
I.D.: Sex: F
S.S.#: - - Ethnic: W
ZIPCode: Height: 160.00 cm
Operator: JT Weight: 66.00 kg
BirthDate: 06.Sep.91 Age: 14
Physician:
Image not for diagnostic use

TOTAL BMC and BMD CV is < 1.0%
C.F. 1.045 1.028 1.000

Region	Area (cm2)	BMC (grams)	BMD (gms/cm2)
L Arm	149.39	113.01	0.756
R Arm	162.47	129.55	0.797
L Ribs	141.47	86.97	0.615
R Ribs	171.19	105.78	0.618
T Spine	91.14	76.90	0.844
L Spine	34.87	30.70	0.880
Pelvis	172.38	197.52	1.146
L Leg	358.23	349.46	0.976
R Leg	334.45	330.87	0.989
SubTot	1615.60	1420.76	0.879
Head	239.35	407.55	1.703
TOTAL	1854.95	1828.31	0.986

HOLOGIC

HOTEL-DIEU DE FRANCE BEYROUTH



o03.Dec.2005 10:13 [318 x 150]
Hologic QDR-4500W (S/N 48937)
Whole Body V8.26a:5

A12030504 Sat 03.Dec.2005 10:01
Name:
Comment: balamand
I.D.: Sex: F
S.S.#: - - Ethnic: W
ZIPCode: Height: 160.00 cm
Operator: JT Weight: 66.00 kg
BirthDate: 06.Sep.91 Age: 14
Physician:
Image not for diagnostic use
TBAR1535 - 1
F.S. 68.00% 0(10.00)%
Head assumes 17.0% brain fat
LBM 73.2% water

Region	Fat (grams)	Lean+BMC (grams)	% Fat (%)
L Arm	1080.8	1654.8	39.5
R Arm	988.6	1959.2	33.5
Trunk	9836.9	18472.8	34.7
L Leg	5394.4	7251.6	42.7
R Leg	5245.0	7534.3	41.0
SubTot	22545.7	36872.7	37.9
Head	965.7	4075.2	19.2
TOTAL	23511.4	40947.8	36.5

HOLOGIC

HOTEL-DIEU DE FRANCE BEYROUTH

Hologic QDR-4500W (S/N 48937) Whole Body V8.26a:5 o03.Dec.2005 10:13	A12030504 Sat 03.Dec.2005 1?:01 Name: Comment: balamand I.D.: Sex: F S.S.#: - - Ethnic: W ZIPCode: Height: 160.00 cm Operator: JT Weight: 66.00 kg BirthDate: 06.Sep.91 Age: 14 Physician:

TBAR1535 - 1
F.S. 68.00% 0(10.00)%

Region	BMC (grams)	Fat (grams)	Lean (grams)	Lean+BMC (grams)	Total (grams)	% Fat (%)
L Arm	113.0	1080.8	1541.8	1654.8	2735.6	39.5
R Arm	129.6	988.6	1829.7	1959.2	2947.8	33.5
Trunk	497.9	9836.9	17974.9	18472.8	28309.7	34.7
L Leg	349.5	5394.4	6902.1	7251.6	12646.0	42.7
R Leg	330.9	5245.0	7203.4	7534.3	12779.3	41.0
SubTot	1420.8	22545.7	35451.9	36872.7	59418.4	37.9
~ Head	407.5	965.7	3667.6	4075.2	5040.9	19.2
TOTAL	1828.3	23511.4	39119.5	40947.8	64459.3	36.5

~assumes 17.0% brain fat
LBM 73.2% water

HOLOGIC

Appendix E: Study One

November 27, 2009

Dear Mr. Abdallah Fazah,

We are glad to inform you that your article entitled
MS No.: PED-00365-2008.R1
Author: Abdallah Fazah
Co-Authors: Fazah, Abdallah; Jacob, Christophe; Moussa, Elie; elhage, rawad; Youssef, Hala; Delamarche, Paul
Activity, Inactivity and Quality of Life among Lebanese Adolescents

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Address for mailing:
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We appreciate your contribution to the journal.

Sincerely yours

Editor-in-Chief
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Pediatrics International

Pediatrics International (2010) ••, ••–•• doi: 10.1111/j.1442-200X.2009.03021.x

Original Article

Activity, inactivity and quality of life among Lebanese adolescents

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Abstract ***Background***: The aim of the present study was to investigate recent overweight and obesity prevalence rates for Lebanese adolescents, and to examine differences in physical activity, screen time (sum of time spent in front of TV, computer, and videogames), and health-related quality of life (HRQOL) for the first time among normal, overweight, and obese adolescents.

Methods: One thousand Lebanese adolescents (14–18 years old) from nine schools participated in the study. Height, weight, physical activity, screen time, and HRQOL variables were assessed using validated self-report questionnaires.

Results: A total of 7.8% of boys and 1.75% of girls were obese, and 22.5% of boys and 12.47% of girls were overweight. Normal-weight boys reported higher physical activity scores at health clubs than obese boys. Normal-weight girls reported higher leisure time and total physical activity scores than obese girls. In the normal-weight group, boys reported higher total screen time than girls. Normal-weight boys reported higher physical functioning scores than their obese peers. Normal-weight girls reported higher physical functioning and average HRQOL scores than obese girls. Normal-weight and overweight boys reported higher average HRQOL scores than girls.

Conclusion: The present study is the first to provide data on physical activity, screen time, and HRQOL among Lebanese adolescents. Despite the need for further research, all those concerned with the pediatric population are urged to develop and implement effective strategies to increase physical activity and improve HRQOL among adolescents based on the present findings.

Key words adolescence, obesity, physical exercise, quality of life.

During the past decades, studies have found an unprecedented rise in the prevalence of overweight and obesity among children and adolescents in many parts of the world.[1,2] Studies have shown that obesity early in life has a definite impact on health associated with many diseases and disorders.[3–6] There is also increasing evidence, however, that adolescent obesity may also be linked to psychosocial disorders. All these complications also have a devastating effect on the economy.[7] From a public health perspective, obesity-related costs are not confined to the billions of dollars spent on direct medical expenses; it also includes indirect cause of lost productivity.[8]

Although research in the field of obesity has undertaken a multidimensional approach, the fact still remains that increases in bodyweight that lead to obesity are caused primarily by a disruption in the delicate homeostasis between energy intake and energy expenditure. Consequently, any parameter that may disrupt this balance may be considered a risk factor for the development of obesity. Physical activity and inactivity are factors that may influence the prevalence of obesity,[9–15] especially because they are modifiable. Research has shown that physical activity in the form of scheduled exercise has definite acute effects on blood lipids, blood pressure, glucose homeostasis and immunological functions, thus it may improve overall health status in overweight and obese subjects irrespective of weight loss.[16] Moreover, evidence suggests that certain forms of physical activity may significantly contribute to psychosocial health and lead to improvement of self-esteem, emotional well-being and self-perception in adolescents.[17–19]

Numerous studies concerned with young populations have been using the Pediatric Quality of Life Inventory (PedsQL) to assess the health-related quality of life (HRQOL) in children and adolescents. Assessment of HRQOL is a subjective method used to measure one's physical, emotional and social health. Some studies have shown that obesity is associated with low HRQOL scores among children and adolescents.[20–22] Indeed, clinical and population-based studies have shown that the HRQOL of adolescents may be lower in overweight and obese subjects.[20,23–26]

In Lebanon, an Asian republic with diverse religious backgrounds located at the east end of the Mediterranean, research on obesity is still in its early stages. Evidence suggests that obesity

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Table 1 Variables used in self-report questionnaire

Anthropometric measurements	Age	Sex	Height	Weight
Physical activity scores	School	Health club	Home	Leisure
Screen time	TV per weekday and per weekend	Computer per weekday and per weekend	Videogame per weekday and per weekend	
Pediatric Quality of Life scores	Physical functioning	Emotional functioning	Social functioning	School functioning

in this region is following the same trend as in Western countries.[27–29] To our knowledge, however, there is no existing literature on physical activity, inactivity, and HRQOL among adolescents in the Middle East.

Thus, the aim of the present study is to assess physical activity, screen time (sum of time spent in front of TV, computer, and videogames), and HRQOL among normal, overweight, and obese adolescents in Lebanon.

Methods

The study population consisted of 1000 adolescents (14–18 years old). Participants were randomly selected from nine schools (three public and six private). The survey was presented in French because all the selected schools taught French as a second language. Each school was visited on separate occasions; our team met with the students during the physical education sessions and provided them with a detailed explanation of the whole survey.

The survey consists of four self-report questionnaires. In part 1, general and anthropometric data were collected. In part 2, a validated questionnaire was used to assess different aspects of physical activity.[30] Data in this section were computed using the MET system (1 MET = 3.5 mL oxygen consumed/kg of bodyweight/min) by means of the compendium of physical activity.[31] The results were expressed in MET/week.

In part 3, inactivity is expressed in hours, and defined as an activity that yields an energy expenditure less than or equal to that at rest (1.5 MET). Inactivity includes television viewing, computer usage and video games playing on an hourly basis, separate timetables were completed for schooldays and weekends.

Finally, in part 4, to assess HRQOL we used the PedsQL 4.0 French version.[21] This questionnaire has been validated, with internal consistency reliability >0.7. It is made up of a total of 23 questions divided across four generic core scales: physical (eight items), emotional (five items), social (five items), and school functioning (five items), in addition to a total score, which is the sum of all four components of the questionnaire. Scores range from 0 to 100, with higher scores representing a better QOL. A summary of the total questionnaire is provided in Table 1.

All protocols used in the present study were approved by the Ethics committee of the University of Balamand in Lebanon and the Ethics committee of the University of Rennes 2 in France.

Data are expressed as mean ± SD. Relations between body mass index (BMI), and variables of physical activity, inactivity, and PedsQL in boys and girls were analyzed using Kruskal–Wallis one-way analysis of variance on ranks; in the event of significance, all pairwise multiple comparison procedures (Dunn's method) was performed. All statistical analysis was completed using SIGMA STAT (Jandal Scientific, San Jose, CA, USA). $P < 0.05$ was accepted as the minimal level of statistical significance.

Results

Some questionnaires were not included in the study due to incomplete data. Subjects older than 18 years of age and those with chronic physical disabilities were exempted from participation. In all, a total of 18 subjects were excluded from the analysis. The final sample included 982 adolescents, with boys representing 42.9%.

Based on international age- and sex-specific cut-off points,[32] the present results show that among Lebanese adolescents, 7.8% of boys and 1.75% of girls are obese, and 22.5% of boys and 12.47% of girls are overweight.

Physical activity among adolescents

Table 2 lists the physical activity scores of the girls who were assessed in the present study. In boys, scores for physical activity at health clubs were higher in the normal-weight group compared to the obese group. In contrast, in girls, leisure time physical activity and total physical activity scores were significantly lower in the obese group as compared to the normal-weight and overweight group. There was also a trend for lower levels of physical

Table 2 Physical activity variables per week (MET) vs BMI grouping (mean ± SD)

	Boys				Girls			
	Normal	Overweight	Obese	*P*	Normal	Overweight	Obese	*P*
School	7.17 ± 8.7	5.54 ± 4.0	5.78 ± 2.3	0.196	5.45 ± 3.5	4.85 ± 2.6	3.70 ± 3.0	0.063
Health club	16.33 ± 31.9	10.47 ± 22.8	8.73 ± 24.4	0.027†	4.39 ± 12.3	1.46 ± 4.8	0	0.067
House	24.00 ± 29.7	25.84 ± 41.5	22.96 ± 24.0	0.719	21.12 ± 29.0	24.79 ± 30.8	14.23 ± 19.5	0.468
Leisure	80.1 ± 85.6	82.16 ± 72.0	46.42 ± 40.2	0.051	56.29 ± 59.8	46.85 ± 51.2	11.45 ± 8.3	0.001†
Total PA	126.58 ± 108.9	122.65 ± 99.8	82.11 ± 51.5	0.097	86.49 ± 72.9	77.54 ± 62.7	29.38 ± 26.9	0.0049†

†Statistically significant difference.
BMI, body mass index; MET, metabolic equivalent; PA, physical activity.

Table 3 Screen time variables (h) vs BMI grouping (mean ± SD)

	Boys				Girls			
	Normal	Overweight	Obese	*P*	Normal	Overweight	Obese	*P*
TV/school day	2.53 ± 1.4	2.77 ± 1.4	2.54 ± 1.2	0.254	2.71 ± 1.4 ±	2.84 ± 1.2	2.65 ± 1.5	0.579
TV/weekend	4.85 ± 2.7	5.1 ± 2.6	5.78 ± 3.1	0.183	5.60 ± 2.8	6.22 ± 2.8	6.45 ± 3.2	0.112
Computer/school day	1.20 ± 1.1	1.17 ± 1.1	1.40 ± 1.0	0.362	0.8 ± 1.0	0.63 ± 0.7	0.25 ± 0.4	0.084
Computer/weekend	3.35 ± 2.4	3.23 ± 2.3	3.85 ± 2.8	0.388	2.08 ± 1.9	1.61 ± 1.5	1.6 ± 0.9	0.122
Videogame/school day	0.41 ± 0.8	0.26 ± 0.5	0.38 ± 0.7	0.357	0.18 ± 0.5	0.22 ± 0.5	0.3 ± 0.6	0.691
Videogame/weekend	1.31 ± 1.9	1.04 ± 1.5	1.10 ± 1.7	0.529	0.66 ± 1.3	0.73 ± 1.3	0.8 ± 1.2	0.701
Total screen time	29.3 ± 13.6	30.4 ± 13.2	33.0 ± 15.2	0.448	26.5 ± 13.5	26.9 ± 10.9	29.6 ± 10.8	0.45

Total screen time: (TV/school day) × 5 + (TV/weekend) + (computer/school day) × 5 + (computer/weekend) + (video game/school day) × 5 + (video game/weekend).
BMI, body mass index.

activity at school ($P = 0.063$) and at health clubs ($P = 0.067$) in the obese group. The results also show a significant gender difference in that boys reported significantly higher total physical activity scores than girls for the normal-weight, overweight and obese groups ($P = 0.0001$, $P = 0.004$, and $P = 0.0024$, respectively).

Inactivity among adolescents

Screen time variables are shown in Table 3. Results yielded no significant group differences. Boys in the normal-weight group, however, had significantly higher total screen time than girls in the same group ($P = 0.004$); this gender difference was not seen across the overweight or obese group.

HRQOL among adolescents

The HRQOL variables are presented in Table 4. In boys, the normal-weight group reported a significantly higher physical functioning score than the obese group. In girls, the normal-weight group reported significantly higher physical functioning and average HRQOL scores as compared to the overweight group, and significantly higher social functioning scores as compared to the obese group. Results also show a significant gender difference ($P = 0.001$), in that boys reported higher average HRQOL scores than girls in both the normal and overweight group, this difference was not found in the obese groups.

Discussion

The present results show that overweight and obesity among Lebanese adolescents is greater in boys than in girls. In a sample of 1000 Lebanese adolescents aged 14–18, we used internationally accepted BMI cut-off points,[32] and found that 7.8% of boys and 1.75% of girls are obese, and 22.5% of boys and 12.47% of girls are overweight. A previous study using National Health and Examination Survey cut-off points found that 7.7% of boys and 2.9% of girls were obese and 29.9% of boys and 14.7% of girls were overweight.[29] Moreover, another recent study using International Obesity Task Force cut-off points found that 10.1% of boys and 4.2% of girls are obese, and 28.8% of boys and 19.0% of girls are overweight.[33] Because none of the BMI cut-off points have been validated against a direct measure of adiposity in Lebanon, there is a need to define new BMI cut-off points that are specific to the populations of the Middle East.

Obesity prevalence among Lebanese adolescents is lower than that of the USA and England,[34,35] but close to those reported in 11–16-year-old Canadian youth, for whom prevalence rates were greater in boys than in girls.[36] With respect to other Mediterranean countries, the present results are comparable to those reported in studies using a similar definition for overweight and obesity. Prevalence rates were very similar to those found in Spain[37] and slightly higher than those reported in Greece.[38]

In the Middle East we found that the prevalence of overweight and obesity among Lebanese boys is much higher than those reported among Turkish boys. In contrast, Lebanese girls have a slightly higher prevalence of overweight and a similar prevalence of obesity compared to Turkish girls.[39] Compared to other Arabian countries, overweight and obesity prevalence is still much lower than that found in Qatar,[27] Bahrain,[40] and Saudi Arabia.[41]

Table 4 Health-related quality of life vs BMI grouping

	Boys				Girls			
	Normal	Overweight	Obese	*P*	Normal	Overweight	Obese	*P*
Physical	84.8 ± 12.7	82.6 ± 13.4	77.1 ± 14.0	0.006†	78.7 ± 13.8	72.3 ± 14.1	76.5 ± 6.5	0.002†
Emotion	69.2 ± 16.0	68.0 ± 16.0	68.5 ± 18.2	0.675	58.8 ± 16.6	53.2 ± 15.7	56 ± 22.3	0.052
Social	85.4 ± 15.5	83.7 ± 15.1	83.3 ± 12.1	0.191	85.4 ± 14.3	80.7 ± 16.5	72.0 ± 6.7	0.0006†
School	76.6 ± 17.4	77.0 ± 15.1	73.3 ± 19.6	0.767	76.4 ± 16.0	74.4 ± 17.3	74.0 ± 10.2	0.518
Average	79.0 ± 11.2	77.8 ± 10.3	75.6 ± 13.1	0.361	74.8 ± 11.0	70.2 ± 10.8	69.6 ± 9.5	0.005†

†Statistically significant difference.
BMI, body mass index.

Physical activity

To our knowledge this is the first attempt to seriously assess physical activity, inactivity and pediatric quality of life among an adolescent population in the Middle East. The present results show a significant gender difference across all groups, in that boys reported higher physical activity levels than girls. This is in accordance with other studies.[42–44]

The present findings show that obese girls have significantly lower leisure time and total physical activity scores than the normal-weight and overweight groups. This may be partially due to the lack of access to public parks and safe playgrounds, which has been known to negatively affect physical activity among adolescents.[45,46] Moreover, obese girls also reported suppressed social HRQOL functioning scores. This may explain why they shy away from participating in sports activities or even any type of group physical activity. This may well be the reason why obese girls reported no use of gyms or health clubs at all.

Further research is needed to determine if excess body fat is reducing the desire and/or interest for physical activity or whether decreased levels of physical activity is the cause of excess body fat. It is in the public health interest to establish physical activity guidelines and provide opportunities for the adolescent community, especially those with excess weight, to increase their levels of physical activity.

Inactivity

Inactivity has been linked to obesity among adolescents.[47,48] Even though some studies show that television viewing, computer use and videogame playing may disrupt the body's energy balance in many ways,[49,50] the present results indicated no significant group differences in screen time variables in boys or in girls. One possible reason may be due to the fact that we assessed only screen time, and subjects might engage in other sedentary activities such as reading, playing cards or listening to music.

Compared with other studies, obese adolescents reported 19.11 ± 8.5 h per week of television viewing whereas US adolescents reported on average 21 h per week.[51] Moreover, total screen time reported by obese boys (33.0 ± 15.2 h) and girls (29.6 ± 10.8 h) was higher when compared to that reported in another study among US boys (15.9 ± 0.53 h) and girls (20.3 ± 1.19 h), respectively.[52]

Health-related quality of life

Numerous studies have demonstrated the impact of obesity on the HRQOL of adolescents. Moreover, there is some evidence that being overweight in childhood or adolescence may also affect future quality of life.[53]

Obese boys reported lower physical functioning scores than normal-weight boys. This finding is comparable to studies in adolescents that reported a decrease in physical functioning but not in emotional and school functioning scores.[54] Poor HRQOL was more pronounced in girls. Indeed, overweight girls reported lower physical functioning and average HRQOL scores than normal-weight girls, and obese girls reported lower social functioning score than normal-weight girls. This may be partially explained with findings from other studies that found that obese adolescent girls have fewer friends[55] and are more socially isolated than their normal-weight peers.[56]

The boys in the normal-weight and overweight group reported higher average HRQOL scores than the girls. This difference was not seen in the obese group. Gender differences in HRQOL seem to disappear as obesity sets in. Thus, obesity among adolescents in Lebanon has similar implications for HRQOL among both boys and girls.

Despite certain limitations such as the use of an indirect measure to assess physical activity and the fact that the results are all self-reported, the present study is the first to provide data on physical activity, inactivity, and HRQOL among Lebanese adolescents. Although there is a need for further research, all those concerned with the pediatric population are urged to develop and implement effective strategies to increase physical activity and improve HRQOL among adolescents based on the present findings.

Acknowledgments

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References

1 Kosti RI, Panagiotakos DB. The epidemic of obesity in children and adolescents in the world. *Cent. Eur. J. Public Health* 2006; **14**: 151–9.
2 World Health Organization. *Obesity: Preventing and Managing the Global Epidemic*. Technical Report Series. WHO, Geneva, 2000.
3 Valerio G, Licenziati MR, Iannuzzi A *et al.* Insulin resistance and impaired glucose tolerance in obese children and adolescents from Southern Italy. *Nutr. Metab. Cardiovasc. Dis.* 2006; **16**: 279–84.
4 Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: The Bogalusa Heart Study. *Pediatrics* 1999; **103**: 1175–82.
5 Weiss R, Dziura J, Burgert TS *et al.* Obesity and the metabolic syndrome in children and adolescents. *N. Engl. J. Med.* 2004; **350**: 2362–74.
6 Ford ES, Mokdad AH, Ajani UA. Trends in risk factors for cardiovascular disease among children and adolescents in the United States. *Pediatrics* 2004; **114**: 1534–44.
7 Finkelstein EA, Fiebelkorn IC, Wang G. National medical spending attributable to overweight and obesity: How much, and who's paying? *Health Aff.* 2003; **W3**: 219–26.
8 Wolf AM, Colditz GA. Current estimates of the economic cost of obesity in the United States. *Obes. Res.* 1998; **6**: 97–106.
9 U.S. Department of Health and Human Services. *Physical activity and Health: A report of the Surgeon General.* Centers for Disease Control and Prevention, Atlanta, GA, 1996.
10 Tsiros MD, Sinn N, Coates AM, Howe PR, Buckley JD. Treatment of adolescent overweight and obesity. *Eur. J. Pediatr.* 2008; **167**: 9–16.
11 Ischander M, Zaldivar F Jr, Eliakim A *et al.* Physical activity, growth, and inflammatory mediators in BMI-matched female adolescents. *Med. Sci. Sports Exerc.* 2007; **39**: 1131–8.
12 Ponjee GA, Janssen EM, Hermans J, van Wersch JW. Regular physical activity and changes in risk factors for coronary heart

disease: A nine months prospective study. *Eur. J. Clin. Chem. Clin. Biochem.* 1996; **34**: 477–83.
13 Ivy JL. Role of exercise training in the prevention and treatment of insulin resistance and non-insulin-dependent diabetes mellitus. *Sports Med.* 1997; **24**: 321–36.
14 Raitakari OT, Taimela S, Porkka KV *et al.* Associations between physical activity and risk factors for coronary heart disease: The Cardiovascular Risk in Young Finns Study. *Med. Sci. Sports Exerc.* 1997; **29**: 1055–61.
15 Knowler WC, Barrett-Connor E, Fowler SE *et al.* Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N. Engl. J. Med.* 2002; **346**: 393–403.
16 Thompson PD, Crouse SF, Goodpaster B, Kelley D, Moyna N, Pescatello L. The acute versus the chronic response to exercise. *Med. Sci. Sports Exerc.* 2001; **33**(Suppl.): S438–45, discussion S452-3.
17 Schmalz DL, Deane GD, Birch LL, Davison KK. A longitudinal assessment of the links between physical activity and self-esteem in early adolescent non-Hispanic females. *J. Adolesc. Health* 2007; **41**: 559–65.
18 Stein C, Fisher L, Berkey C, Colditz G. Adolescent physical activity and perceived competence: Does change in activity level impact self-perception? *J. Adolesc. Health* 2007; **40**: 462.e1–8.
19 Steptoe A, Butler N. Sports participation and emotional wellbeing in adolescents. *Lancet* 1996; **347**(9018): 1789–92.
20 Schwimmer JB, Burwinkle TM, Varni JW. Health-related quality of life of severely obese children and adolescents. *JAMA* 2003; **289**: 1813–19.
21 Varni JW, Seid M, Rode CA. The PedsQL: Measurement model for the Pediatric Quality of Life Inventory. *Med. Care* 1999; **37**: 126–39.
22 Williams J, Wake M, Hesketh K, Maher E, Waters E. Health-related quality of life of overweight and obese children. *JAMA* 2005; **293**: 70–76.
23 Kolotkin RL, Crosby RD, Kosloski KD, Williams GR. Development of a brief measure to assess quality of life in obesity. *Obes. Res.* 2001; **9**: 102–11.
24 Ball K, Crawford D, Kenardy J. Longitudinal relationships among overweight, life satisfaction, and aspirations in young women. *Obes. Res.* 2004; **12**: 1019–30.
25 Stunkard A, Burt V. Obesity and the body image. II. Age at onset of disturbance in the body image. *Am. J. Psychiatry* 1967; **123**: 1443–7.
26 Crabtree VM, Varni JW, Gozal D. Health-related quality of life and depressive symptoms in children with suspected sleep disordered breathing. *Sleep* 2004; **27**: 1131–8.
27 Bener A. Prevalence of obesity, overweight, and underweight in Qatari adolescents. *Food Nutr. Bull.* 2006; **27**: 39–45.
28 Al-Isa AN. Body mass index, overweight and obesity among Kuwaiti intermediate school adolescents aged 10–14 years. *Eur. J. Clin. Nutr.* 2004; **58**: 1273–7.
29 Sibai AM, Hwalla N, Adra N, Rahal B. Prevalence and covariates of obesity in Lebanon: Findings from the first epidemiological study. *Obes. Res.* 2003; **11**: 1353–61.
30 Deheeger M, Rolland-Cachera MF, Fontvieille AM. Physical activity and body composition in 10 year old French children: Linkages with nutritional intake? *Int. J. Obes. Relat. Metab. Disord.* 1997; **21**: 372–9.
31 Ainsworth BE, Haskell WL, Leon AS *et al.* Compendium of physical activities: Classification of energy costs of human physical activities. *Med. Sci. Sports Exerc.* 1993; **25**: 71–80.
32 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ* 2000; **320**(7244): 1240–43.
33 Chakar H, Salameh PR. Adolescent obesity in Lebanese private schools. *Eur. J. Public Health* 2006; **16**: 648–51.
34 Baskin ML, Ard J, Franklin F, Allison DB. National prevalence of obesity: Prevalence of obesity in the United States. *Obes. Rev.* 2005; **6**: 5–7.
35 Information Centre for Health and Social Care. *Health Survey for England.* Updating of trend tables to include childhood obesity data. Health and Social Care Information Centre, London, 2004. [Accessed 6 December 2007.] Available from URL: http://www.ic.nhs.uk/statistics-and-data-collections/health-and-lifestyles-related-surveys/health-survey-for-england/health-survey-for-england-2004-updating-of-trend-tables-to-include-childhood-obesity-data
36 Pickett W, King MA, Boyce WF, Katzmaryzk PT, Janssen I. Overweight and obesity in Canadian adolescents and their association with dietary habits and physical activity patterns. *J. Adolesc. Health* 2004; **35**: 360–67.
37 Serra-Majem L, Aranceta Bartrina J, Pérez-Rodrigo C, Ribas-Barba L, Delgado-Rubio A. Prevalence and determinants of obesity in Spanish children and young people. *Br. J. Nutr.* 2006; **96** (Suppl. 1): S67–72.
38 Kosti RI, Panagiotakos DB, Mihas CC *et al.* Dietary habits, physical activity and prevalence of overweight/obesity among adolescents in Greece: The Vyronas study. *Med. Sci. Monit.* 2007; **13**: CR437–44.
39 Oner N, Vatansever U, Sari A *et al.* Prevalence of underweight, overweight and obesity in Turkish adolescents. *Swiss. Med. Wkly* 2004; **134**: 529–33.
40 Al-Sendi AM, Shetty P, Musaiger AO. Prevalence of overweight and obesity among Bahraini adolescents: A comparison between three different sets of criteria. *Eur. J. Clin. Nutr.* 2003; **57**: 471–4.
41 Al-Almaie SM. Prevalence of obesity and overweight among Saudi adolescents in Eastern Saudi Arabia. *Saudi. Med. J.* 2005; **26**: 607–11.
42 Eck LH, Klesges RC, Hanson CL, Slawson D. Children familial risk for obesity: An examination of dietary intake, physical activity and weight status. *Int. J. Obes.* 1992; **16**: 71–8.
43 Gazzaniga JM, Burns TL. Relationship between diet composition and body fatness with adjustment for resting energy expenditure and physical activity, in preadolescent children. *Am. J. Clin. Nutr.* 1993; **58**: 21–8.
44 McMurray RG, Harrell JS, Levine A, Gansky S. Childhood obesity elevates blood pressure and total cholesterol independent of physical activity. *Int. J. Obes.* 1995; **19**: 881–6.
45 Cohen DA, Ashwood JS, Scott MM *et al.* Public parks and physical activity among adolescent girls. *Pediatrics* 2006; **118**: 1381–9.
46 Pate RR, Colabianchi N, Porter D, Almeida MJ, Lobelo F, Dowda M. Physical activity and neighborhood resources in high school girls. *Am. J. Prev. Med.* 2008; **34**: 413–19.
47 Monda KL, Popkin BM. Cluster analysis methods help to clarify the activity-BMI relationship of Chinese Youth. *Obes. Res.* 2005; **13**: 1042–51.
48 Must A, Tybor DJ. Physical activity and sedentary behavior: A review of longitudinal studies of weight adiposity in youth. *Int. J. Obes. (Lond.)* 2005; **29**(Suppl. 2): S84–96.
49 Epstein LH, Roemmich JN, Paluch RA, Raynor HA. Physical activity as a substitute for sedentary behavior in youth. *Ann. Behav. Med.* 2005; **29**: 200–9.
50 Matheson DM, Killen JD, Wang Y, Varady A, Robinson TN. Children's food consumption during television viewing. *Am. J. Clin. Nutr.* 2004; **79**: 1088–94.
51 Research NM. *Nielsen's 1998 Report on Television.* Nielsen Media Research, New York, 1998.
52 Boone JE, Gordon-Larsen P, Adair LS, Popkin BM. Screen time and physical activity during adolescence: Longitudinal effects on obesity in young adulthood. *Int. J. Behav. Nutr. Phys. Act.* 2007; **4**: 26.

53 Story MT, Neumark-Stzainer DR, Sherwood NE *et al.* Management of child and adolescent obesity: Attitudes, barriers, skills, and training needs among health care professionals. *Pediatrics* 2002; **110**: 210–14.
54 Pinhas-Hamiel O, Singer S, Pilpel N, Fradkin A, Modan D, Reichman B. Health-related quality of life among children and adolescents: Associations with obesity. *Int. J. Obes. (Lond.)* 2006; **30**: 267–72.
55 Strauss RS, Pollack HA. Social marginalization of overweight children. *Arch. Pediatr. Adolesc. Med.* 2003; **157**: 746–52.
56 Zeller MH, Reiter-Purtill J, Ramey C. Negative peer perceptions of obese children in the classroom environment. *Obesity* 2008; **16**: 755–62.

Appendix F: Study Two

FROM; Dr ADEL E.BERBARI
TO; Mr ABDALLAH FAZAH
September 25, 2009

I am pleased to inform you that your manuscript titled " BODY MASS INDEX AND BODY FAT IN LEBANESE FEMALE ADOLESCENTS" serial no.2009/4 has been accepted for publication. You will be informed subsequently of the volume and issue in which it will appear.

Sincerely

ADEL E.BERBARI, M.D., FACP, FAHA, FICA
PROFESSOR OF MEDICINE/PHYSIOLOGY
EDITOR IN CHIEF
LEBANESE MEDICAL JOURNAL

ARTICLE ORIGINAL/ORIGINAL ARTICLE

BODY MASS INDEX AND BODY FAT IN LEBANESE FEMALE ADOLESCENTS

http://www.lebanesemedicaljournal.org/articles/58-1/original6.pdf

Abdallah FAZAH[1], Christophe JACOB[1], Rawad EL-HAGE[1,2], Paul DELAMARCHE[3], Elie MOUSSA[1]

Fazah A, Jacob C, El-Hage R, Delamarche P, Moussa E. Body mass index and body fat in Lebanese female adolescents. J Med Liban 2010 ; 58 (2) : 97-100.

Fazah A, Jacob C, El-Hage R, Delamarche P, Moussa E. Indice de masse corporelle et masse grasse chez les adolescentes libanaises. J Med Liban 2010 ; 58 (2) :97-100.

ABSTRACT • OBJECTIVE : The aim of this study is to investigate the relation between body mass index (BMI) and body fat (BF) among Lebanese female adolescents.

METHODS : 51 Lebanese females aged 12 to 18 years participated in this study. BMI was calculated as weight/height². Adiposity was measured by dual energy X-ray absorptiometry (DEXA).

RESULTS : Correlation coefficient of percent body fat (%BF) with BMI is 0.82. Correlation coefficient of fat mass (BF) with BMI is 0.93. The two linear regression formulas are : %BF = 6.89 + (1.1 *BMI) and BF = – 0.425 + (1.29 *BMI).

CONCLUSION : Correlations of BMI with DEXA measurements were higherwith BFthan %BF. For a given BMI, Lebanese girls have a higherthan expected %BF. Based on the current findings, there may be a need to develop new cutoff points. From a public health perspective, this may considerably increase the prevalence of obesity among Lebanese female adolescents.

RÉSUMÉ • OBJECTIF : Le but de ce travail est d'étudier la relation entre le pourcentage de masse grasse et l'indice de masse corporelle (IMC) chez les adolescentes libanaises

MÉTHODE : 51 adolescentes libanaises âgées de 12 à 18 ans ont participé à cette étude. L'indice de masse corporelle était calculé à partir de la taille et du poids (poids en kg divisé par la taille en mètre au carré). Le pourcentage de masse grasse était mesuré par la méthode DEXA.

RÉSULTATS : L'indice de masse corporelle (IMC) était positivement corrélé au pourcentage de masse grasse (r = 0,82 ; p < 0,0001) et à la masse grasse (kg) (r = 0,93 ; p < 0,0001). Les équations reliant IMC et pourcentage de masse grasse (%MG) et masse grasse (MG) étaient respectivement : %MG = 6,89 + (1,1 *IMC) et MG = – 0,425 + (1,29 *IMC).

CONCLUSION : Dans cette étude le pourcentage de masse grasse ainsi que la masse grasse étaient très bien corrélés avec l'IMC. Cependant, pour un IMC donné, les adolescentes libanaises affichent un pourcentage de masse grasse beaucoup plus élevé que prévu. Cette étude suggère donc qu'il faille modifier les valeurs de références de l'IMC correspondant au surpoids et à l'obésité. D'un point de vue santé publique cela devrait permettre de mieux connaître les problèmes de surcharge pondérale et leur prévalence chez les adolescentes libanaises qui à priori sont considérablement sous-estimés.

INTRODUCTION

After being classified as a disease by the World Health Organization (WHO), obesity-related research has expanded widely. By definition, obesity is a pathological condition associated with excess adiposity [1-2]. The prevalence of overweight and obesity has increased in many parts of the world [3-4]. An even more shocking phenomenon is the global rise among children and adolescents [5]. The association of obesity with numerous health disorders has amplified the need for accurate assessment techniques of body fat (BF). However, these methods are usually complicated, expensive and time consuming, therefore making them inappropriate for population-based studies. This led to the development of indirect methods to estimate adiposity, among these, the most widely used is the body mass index (BMI), which is defined as weight (kg)/height squared (m²) [6]. Even though it is a measure of excess weight rather than excess body fat, studies have shown a high correlation between BMI and body fat [7-9]. By using appropriate cutoff points, BMI may be used to assess overweight and obesity. Adults with a BMI 25-30 are classified as overweight, whereas those with BMI > 30 are classified as obese [9]. Other studies have also defined obesity based on BF. These studies suggest a body fat percent (%BF) of at least 25% of total body mass for men and 30-33% for women [10-11].

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In children, age and sex specific BMI cutoff points have been developed and validated against direct measures of adiposity [12]. However, defining overweight and obesity in children is complicated by the fact that weight varies with height as children grow, this process is best described by Horlick in the title of his article, "Measuring a Moving Target" [13]. Moreover, several studies have suggested that the relationship between BMI and BF is affected by factors such as ethnicity and body build [14-18]. These limitations may become an important issue when assessing obesity in specific populations or when comparing ethnic groups with distinctively different body proportions. Indeed, these studies have suggested that universal cutoff points may not be used to accurately assess overweight and obesity in certain Asian populations and therefore they recommend the use of lower BMI cutoff points to define obesity [16-18].

In Lebanon and the Middle East, universal BMI cutoff points have been used to assess obesity [19]. However, the relation between BMI and BF has never been assessed. Thus the aim of this study is to determine the relation between BMI and BF among Lebanese female adolescents.

METHODS

Subjects

Fifty-one adolescent females aged 12 to 18 years were recruited from different schools to participate in this study. At the time of this study all subjects were at least twelve months ahead of their first menstruation.

Study design

Body weight was measured using an electronic scale (Taurus, Quasar) with a precision of 140 kg/100 g, height was measured to the nearest 0.5 cm using a stadiometer (Seca model 222). BF was measured by dual energy X-ray absorptiometry (DEXA Hologic QDR-4500W, Hologic Inc., Waltham, MA). The coefficient of variation was 0.54% for fat-free mass, and 1.13% for fat mass. Testing took place in a hospital setting under the direct administration of accredited technicians.

TABLE I
DESCRIPTIVE CHARACTERISTICS
OF THE FEMALE ADOLESCENTS (N = 51)

	Mean	SD	Range
Age (yrs)	15.06	1.67	12-18
Height (cm)	160.18	5.5	150-172
Weight (kg)	65.53	13.40	38.00-97.00
BMI (kg/m^2)	25.46	4.64	15.41-35.69
Fat-free mass (kg)	39.97	5.63	28.40-53.82
BF (kg)	23.58	7.98	8.90-44.25
% BF	34.93	6.21	21.00-46.60

SD : standard deviation **BMI** : body mass index
BF : body fat **%BF**: body fat percent

A written consent was obtained from the subjects and their parents. Participation in the study was voluntary and subjects were free to withdraw at any time.

All procedures used in this research have been approved by both the Ethics committee of the University of Balamand in Lebanon, and that of the University of Rennes in France.

Statistics

The means and standard deviations were calculated for all clinical data (Table I). Linear regression analysis models were used to test the relationship between fat mass percentage and BMI, as well as fat mass with BMI and r^2 coefficients were reported. Data was analyzed with NCSS (2001). Alevel of significance of $p < 0.05$ was used.

RESULTS

Description of study subjects

Descriptive information of the subjects are found in Table I, the participants were classified according to the widely used age and gender specific BMI cutoff points [11] as follows, 16 normal weight, 24 overweight, and 11 obese.

Correlation between DEXAmeasurements and anthropometric measurements

Correlation of %BF by DEXA with BMI is 0.82. Correlation of BF by DEXA with BMI is 0.93, both values at $p < 0.0001$. Figure 1 shows a scatter diagram of the association between %BF by DEXA and BMI, including best fit lines for the regression of %BF on BMI. On the other hand, figure 2 shows a scatter diagram of the association between BF by DEXAand BMI.

The two linear regression formulas are :

$$\%BF = 6.89 + (1.1 * BMI) \text{ and}$$

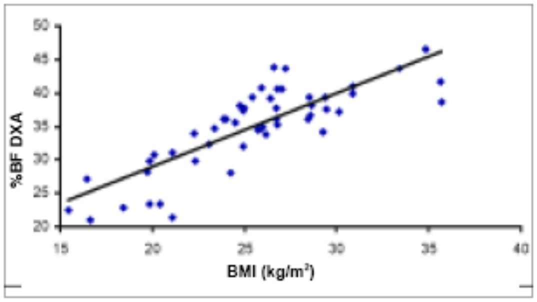
$$BF = -0.425 + (1.29 * BMI).$$

After checking the correlations, we tried to compare %BF as estimated from the internationally accepted BMI cutoff points, and %BF as found by DEXA measurements in this study. Most studies suggest that %BF cutoff values for obesity in adolescent girls is between 30-35% [20-22]. By using the linear regression formula obtained in our study, a BMI of 30 kg/m^2 yields a %BF of 39.89. This value falls above the accepted range. In fact, it is even slightly higher than that found in adult female Taiwanese subjects [23]. Based on the current findings, a %BF of 33 would reflect a BMI of 23 kg/m^2.

DISCUSSION

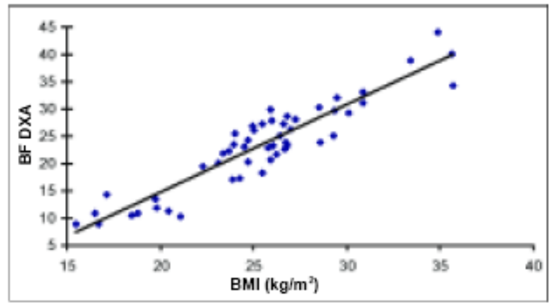
As mentioned earlier, several studies have suggested that the relationship between BMI and %BF may differ between populations. Their findings recommend the development of population specific BMI cutoff points based on age, gender, and ethnicity [9-11].

This study shows that BMI is highly correlated with measures of body fat obtained by DEXA. This finding supports previous research which shows that although



%BF : body fat percent **DEXA** : dual energy X-ray absorptiometry
BMI : body mass index

FIGURE 1
Correlation of %BF by DEXAwith BMI in girls
($r = 0.82$, $p < 0.0001$)



%BF : body fat (kg) **DEXA** : dual energy X-ray absorptiometry
BMI : body mass index

FIGURE 2
Correlation of body fat by DEXAwith BMI in girls
($r = 0.93$, $p < 0.0001$)

BMI has some flaws, it can be used for the initial screening of obesity [24-25].

The correlations of BMI with DEXA measurements in this study group were higher with FM ($r = 0.93$) than %BF ($r = 0.82$). These results were similar to that reported in a study conducted in Italian children adolescents [24].

From these results we conclude that even though BMI is used to assess obesity in epidemiological studies and initial screening, it provides only a limited insight to the degree of obesity based on the percent body fat. Because of this, results should be interpreted with caution since the cutoff points currently used cannot detect subjects who have a higher than expected %BF for a given BMI. Perhaps this may show that the low prevalence of obesity previously reported in adolescent girls [19] may be more due to methodological causes.

One of the limitations of this study is the fact that it is conducted only in adolescent girls. However, our interest was restricted to this group because previous epidemiological studies reported very low prevalence of obesity in this population [19].

Finally, based on the current findings, one can suggest that a BMI cutoff point of 23 may be a more suitable alternative for the assessment of obesity in adolescent girls. From a public health perspective, this finding may considerably increase the prevalence of obesity among Lebanese female adolescents.

ACKNOWLEDGEMENTS

This study was funded by a grant from the University of Balamand Research Committee and the "Projet Cèdre" Committee.

REFERENCES

1. Reilly JJ. Descriptive epidemiology and health consequences of childhood obesity. Best Pract Res Clin Endocrinol Metab 2005 ; 19 (3) : 327-41.
2. Wabitsch M. Overweight and obesity in European children : definition and diagnostic procedures, risk factors and consequences for later health outcome. Eur J Pediatr 2000 ; 159 : S8-S13.
3. Kuczmarski RJ, Flegal KM, Campbell SM et al. Increasing prevalence of overweight among US adults. The National Health Nutrition Examination Surveys, 1960-91. JAMA1994 ; 272 : 205-11.
4. James WP. Epidemiology of obesity. Int J Obes 1992 ; 16 (Suppl 2) : S23-S26.
5. Kosti RI, Panagiotakos DB. The epidemic of obesity in children and adolescents in the world. Cent Eur J Public Health 2006 ; 14 (4) : 151-9.
6. Sweeting H. Measurement and definitions of obesity in childhood and adolescence : a field guide for the uninitiated. Nut J 2007 ; 6 : 32.
7. Haslam DW, James WP. Obesity. Lancet 2005 ; 366 : 1197-09.
8. Goulding A, Gold E, Canna R et al. DEXAsupports the use of BMI as a measure of fatness in young girls. Int J Obes 1996 ; 20 : 1014-21.
9. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. World Health Organization : Geneva, 2000.
10. Wellens RJ, Roche AF, Khamis HJ et al. Relationships between body mass index and body composition. Obes Res 1996 ; 4 : 35-44.
11. Frankenfield DC, Rowe WA, Cooney RN et al. Limits of body mass index to detect obesity and predict body composition. Nutrition 2001 ; 17 (1) : 26-30.
12. Cole TJ, Bellizzi MC, Flegal KM et al. Establishing a standard definition for child overweight and obesity worldwide : international survey. BMJ 2000 ; 320 (7244) : 1240-43.
13. Horlick M. Body mass index in childhood – measuring a moving target. J Clin Endocrinol Metab 2001 ; 86 (9) : 4059-60.
14. Rush E, Plank L, Chandu V et al. Body size, body composition, and fat distribution : a comparison of young New Zealand men of European, Pacific Island, and Asian Indian ethnicities. N Z Med J 2004 ; 117 (1207) U1203.
15. Deurenberg P, Deurenberg-Yap M. Differences in body-composition assumptions across ethnic groups : practical consequences. Curr Opin Clin Nutr Metab Care 2001 ; 4 (5) : 377-83.
16. He M, Tan KCB, E T S L et al. Body fat determination by

dual energy X-ray absorptiometry and its relation to body mass index and waist circumference in Hong Kong Chinese. Int J Obesity 2001 ; 25 : 748-52.

17. Chang CJ, CH Wu, CS Chang et al. Low body mass index but high percent body fat in Taiwanese subjects : implications of obesity cutoffs. Int J Obesity 2003 ; 27 : 253-59.
18. Deurenberg-Yap M, Schmidt G, van Staveren WA. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. Int J Obesity 2000 ; 24 : 1011-17.
19. Sibai AM, Hwalla N, Adra N et al. Prevalence and covariates of obesity in Lebanon : findings from the first epidemiological study. Obes Res 2003 ; 11 (11) : 1353-61.
20. Weststrate JA, Deurenberg P. Body composition in children : proposal for a method for calculating body fat percentage from total body density or skinfold-thickness measurements. Am J Clin Nutr 1989 ; 50 : 1104-15.
21. Taylor RW, Jones IE, Williams SM, Goulding A. Body fat percentages measured by dual-energy X-ray absorptiometry corresponding to recently recommended body mass index cutoffs for overweight and obesity in children and adolescents aged 3-18 y. Am J Clin Nutr 2002 ; 76 : 1416-21.
22. Sardinha LB, Going SB, Teixeira PJ, Lohman TG. Receiver operating characteristic analysis of body mass index, triceps skinfold thickness, and arm girth for obesity screening in children and adolescents. Am J Clin Nutr 1999 ; 70 : 1090-5.
23. Chang CJ, Wu CH, Chang CS et al. Low body mass index but high percent body fat in Taiwanese subjects : implications of obesity cutoffs. Int J Obes 2003 ; 27 (2) : 253-9.
24. Pietrobelli A, Faith MS, Allison DB et al. Body mass index as a measure of adiposity among children and adolescents : a validation study. J Pediatr 1998 ; 132 (2) : 204-10.
25. Goran MI, Driscoll P, Johnson R et al. Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. Am J Clin Nutr 1996 ; 63 (3) : 299-305.

Appendix G: Study Three

Date: Sep 29, 2010
To: "Abdallah Fazah" abdallah.fazah@balamand.edu.lb
From: "Science & Sports" ppesquies@dbmail.com
Subject: SCISPO - Your Submission

Ms. Ref. No.: SCISPO-D-10-00047R1
Title: Taking physical activity level into account improves body fat estimation in girls
Science & Sports

Dear Mr. Abdallah Fazah,

I am pleased to confirm that your paper "Taking physical activity level into account improves body fat estimation in girls" has been accepted for publication in Science & Sports.

Thank you for submitting your work to this journal.

With kind regards,

Pierre Pesquiès
Editor in Chief / Redacteur en chef
Science & Sports

Appendix H: Compendium of Physical Activities

APPENDIX 1. Continued

02060	5.5	Conditioning exercise,	Health club exercise, general (T 160)
02065	6.0	Conditioning exercise,	Stair-treadmill ergometer, general
02070	9.5	Conditioning exercise,	Rowing, stationary ergometer, general
02071	3.5	Conditioning exercise,	Rowing, stationary, 50 W, light effort
02072	7.0	Conditioning exercise,	Rowing, stationary, 100 W, moderate effort
02073	8.5	Conditioning exercise,	Rowing, stationary, 150 W, vigorous effort
02074	12.0	Conditioning exercise,	Rowing, stationary, 200 W, very vigorous effort
02080	9.5	Conditioning exercise,	Ski machine, general
02090	6.0	Conditioning exercise,	Slimnastics
02100	4.0	Conditioning exercise,	Stretching, hatha yoga
02110	6.0	Conditioning exercise,	Teaching aerobic exercise class
02120	4.0	Conditioning exercise,	Water aerobics, water calisthenics
02130	3.0	Conditioning exercise,	Weight lifting (free, nautilus or universal-type), light or moderate effort, light workout, general
02135	1.0	Conditioning exercise,	Whirlpool, sitting
03010	6.0	Dancing,	Aerobic, ballet or modern, twist
03015	6.0	Dancing,	Aerobic, general
03020	5.0	Dancing,	Aerobic, low impact
03021	7.0	Dancing,	Aerobic, high impact
03025	4.5	Dancing,	General
03030	5.5	Dancing,	Ballroom, fast (disco, folk, square) (T 125)
03040	3.0	Dancing,	Ballroom, slow (e.g., waltz, foxtrot, slow dancing)
04001	4.0	Fishing and hunting,	Fishing, general
04010	4.0	Fishing and hunting,	Digging worms, with shovel
04020	5.0	Fishing and hunting,	Fishing from river bank and walking
04030	2.5	Fishing and hunting,	Fishing from boat, sitting
04040	3.5	Fishing and hunting,	Fishing from river bank, standing (T 660)
04050	6.0	Fishing and hunting,	Fishing in stream, in waders (T 670)
04060	2.0	Fishing and hunting,	Fishing, ice, sitting
04070	2.5	Fishing and hunting,	Hunting, bow and arrow or crossbow
04080	6.0	Fishing and hunting,	Hunting, deer, elk, large game (T 710)
04090	2.5	Fishing and hunting,	Hunting, duck, wading
04100	5.0	Fishing and hunting,	Hunting, general
04110	6.0	Fishing and hunting,	Hunting, pheasants or grouse (T 680)
04120	5.0	Fishing and hunting,	Hunting, rabbit, squirrel, prairie chick, raccoon, small game (T 690)
04130	2.5	Fishing and hunting,	Pistol shooting or trap shooting, standing
05010	2.5	Home activities,	Carpet sweeping, sweeping floors
05020	4.5	Home activities,	Cleaning, heavy or major (e.g., wash car, wash windows, mop, clean garage), vigorous effort
05030	3.5	Home activities,	Cleaning, house or cabin, general
05040	2.5	Home activities,	Cleaning, light (dusting, straightening up, vacuuming, changing linen, carrying out trash), moderate effort
05041	2.3	Home activities,	Wash dishes-standing or in general (not broken into stand/walk components)
	2.3	Home activities,	Wash dishes; clearing dishes from table-walking
05050	2.5	Home activities,	Cooking or food preparation-standing or sitting or in general (not broken into stand/walk components)
05051	2.5	Home activities,	Serving food, setting table-implied walking or standing
05052	2.5	Home activities,	Cooking or food preparation-walking
05055	2.5	Home activities,	Putting away groceries (e.g., carrying groceries, shopping without a grocery cart)
05056	8.0	Home activities,	Carrying groceries upstairs
05060	3.5	Home activities,	Food shopping, with grocery cart
05065	2.0	Home activities,	Standing-shopping (non-grocery shopping)
05066	2.3	Home activities,	Walking-shopping (non-grocery shopping)
05070	2.3	Home activities,	Ironing
05080	1.5	Home activities,	Sitting, knitting, sewing, light wrapping (presents)
05090	2.0	Home activities,	Implied standing-laundry, fold or hang clothes, put clothes in washer or dryer, packing suitcase
05095	2.3	Home activities,	Implied walking-putting away clothes, gathering clothes to pack, putting away laundry
05100	2.0	Home activities,	Making bed
05110	5.0	Home activities,	Maple syruping/sugar bushing (including carrying buckets, carrying wood)
05120	6.0	Home activities,	Moving furniture, household
05130	5.5	Home activities,	Scrubbing floors, on hands and knees
05140	4.0	Home activities,	Sweeping garage, sidewalk or outside of house
05145	7.0	Home activities,	Moving household items, carrying boxes
05146	3.5	Home activities,	Standing-packing/unpacking boxes, occasional lifting of household items light-moderate effort
05147	3.0	Home activities,	Implied walking-putting away household items-moderate effort
05150	9.0	Home activities,	Move household items upstairs, carrying boxes or furniture
05160	2.5	Home activities,	Standing-light (pump gas, change light bulb, etc.)
05165	3.0	Home activities,	Walking-light, noncleaning (ready to leave, shut/lock doors, close windows, etc.)
05170	2.5	Home activities,	Sitting-playing with child(ren)-light
05171	2.8	Home activities,	Standing-playing with child(ren)-light
05175	4.0	Home activities,	Walk/run-playing with child(ren)-moderate
05180	5.0	Home activities,	Walk/run-playing with child(ren)-vigorous
05185	3.0	Home activities,	Child care: sitting/kneeling-dressing, bathing, grooming, feeding, occasional lifting of child-light effort
05186	3.5	Home activities,	Child care: standing-dressing, bathing, grooming, feeding, occasional lifting of child-light effort
06010	3.0	Home repair,	Airplane repair
06020	4.5	Home repair,	Automobile body work
06030	3.0	Home repair,	Automobile repair
06040	3.0	Home repair,	Carpentry, general, workshop (T 620)
06050	6.0	Home repair,	Carpentry, outside house (T 640), installing rain gutters
06060	4.5	Home repair,	Carpentry, finishing or refinishing cabinets or furniture
06070	7.5	Home repair,	Carpentry, sawing hardwood
06080	5.0	Home repair,	Caulking, chinking log cabin
06090	4.5	Home repair,	Caulking, except log cabin
06100	5.0	Home repair,	Cleaning gutters
06110	5.0	Home repair,	Excavating garage
06120	5.0	Home repair,	Hanging storm windows
06130	4.5	Home repair,	Laying or removing carpet
06140	4.5	Home repair,	Laying tile or linoleum
06150	5.0	Home repair,	Painting, outside house (T 650)
06160	4.5	Home repair,	Painting, papering, plastering, scraping, inside house, hanging sheet rock, remodeling (T 630)
06170	3.0	Home repair,	Put on and removal of tarp-sailboat
06180	6.0	Home repair,	Roofing
06190	4.5	Home repair,	Sanding floors with a power sander
06200	4.5	Home repair,	Scrape and paint sailboat or powerboat
06210	5.0	Home repair,	Spreading dirt with a shovel
06220	4.5	Home repair,	Wash and wax hull of sailboat, car, powerboat, airplane
06230	4.5	Home repair,	Washing fence
06240	3.0	Home repair,	Wiring, plumbing
07010	0.9	Inactivity, quiet	Lying quietly, reclining (watch television), lying quietly in bed-awake

APPENDIX 1: Continued

07020	1.0	Inactivity, quiet	Sitting quietly (riding in a car, listening to a lecture or music, watch television or a movie)
07030	0.9	Inactivity, quiet	Sleeping
07040	1.2	Inactivity, quiet	Standing quietly (standing in a line)
07050	1.0	Inactivity, light	Recline-writing
07060	1.0	Inactivity, light	Recling-talking or talking on phone
07070	1.0	Inactivity, light	Recline-reading
08010	5.0	Lawn and garden,	Carrying, loading or stacking wood, loading/unloading or carrying lumber
08020	6.0	Lawn and garden,	Chopping wood, splitting logs
08030	5.0	Lawn and garden,	Clearing land, hauling branches
08040	5.0	Lawn and garden,	Digging sandbox
08050	5.0	Lawn and garden,	Digging, spading, filling garden (T 590)
08060	6.0	Lawn and garden,	Gardening with heavy power tools, tilling a garden (see occupation, shoveling)
08080	5.0	Lawn and garden,	Laying crushed rock
08090	5.0	Lawn and garden,	Laying sod
08095	5.5	Lawn and garden,	Mowing lawn, general
08100	2.5	Lawn and garden,	Mowing lawn, riding mower (T 550)
08110	6.0	Lawn and garden,	Mowing lawn, walk, hand mower (T 570)
08120	4.5	Lawn and garden,	Mowing lawn, walk, power mower (T 590)
08130	4.5	Lawn and garden,	Operating snow blower, walking
08140	4.0	Lawn and garden,	Planting seedlings, shrubs
08150	4.5	Lawn and garden,	Planting trees
08160	4.0	Lawn and garden,	Raking lawn (T 600)
08170	4.0	Lawn and garden,	Raking roof with snow rake
08180	3.0	Lawn and garden,	Riding snow blower
08190	4.0	Lawn and garden,	Sacking grass, leaves
08200	6.0	Lawn and garden,	Shoveling, snow, by hand (T 610)
08210	4.5	Lawn and garden,	Trimming shrubs or trees, manual cutter
08215	3.5	Lawn and garden,	Trimming shrubs or trees, power cutter
08220	2.5	Lawn and garden,	Walking, applying fertilizer or seeding a lawn
08230	1.5	Lawn and garden,	Watering lawn or garden, standing or walking
08240	4.5	Lawn and garden,	Weeding, cultivating garden (T 580)
08245	5.0	Lawn and garden,	Gardening, general
08250	3.0	Lawn and garden,	Implied walking/standing-picking up yard, light
09010	1.5	Miscellaneous,	Sitting, card playing, playing board games
09020	2.0	Miscellaneous,	Standing-drawing (writing), casino gambling
09030	1.3	Miscellaneous,	Sitting-reading, book, newspaper, etc.
09040	1.8	Miscellaneous,	Sitting-writing, desk work
09050	1.8	Miscellaneous,	Standing-talking or talking on the phone
09055	1.5	Miscellaneous,	Sitting-talking or talking on the phone
09060	1.8	Miscellaneous,	Sitting-studying, general, including reading and/or writing
09065	1.8	Miscellaneous,	Sitting-in class, general, including note-taking or class discussion
09070	1.8	Miscellaneous,	Standing-reading
10010	1.8	Music playing,	Accordion
10020	2.0	Music playing,	Cello
10030	2.5	Music playing,	Conducting
10040	4.0	Music playing,	Drums
10050	2.0	Music playing,	Flute (sitting)
10060	2.0	Music playing,	Horn
10070	2.5	Music playing,	Piano or organ
10080	3.5	Music playing,	Trombone
10090	2.5	Music playing,	Trumpet
10100	2.5	Music playing,	Violin
10110	2.0	Music playing,	Woodwind
10120	2.0	Music playing,	Guitar, classical, folk (sitting)
10125	3.0	Music playing,	Guitar, rock and roll band (standing)
10130	4.0	Music playing,	Marching band, playing an instrument, baton twirling (walking)
10135	3.5	Music playing,	Marching band, drum major (walking)
11010	4.0	Occupation,	Bakery, general
11020	2.3	Occupation,	Bookbinding
11030	6.0	Occupation,	Building road (including hauling debris, driving heavy machinery)
11035	2.0	Occupation,	Building road, directing traffic (standing)
11040	3.5	Occupation,	Carpentry, general
11050	8.0	Occupation,	Carrying heavy loads, such as bricks
11060	8.0	Occupation,	Carrying moderate loads up stairs, moving boxes (16–40 pounds)
11070	2.5	Occupation,	Chambermaid
11080	6.5	Occupation,	Coal mining, drilling coal, rock
11090	6.5	Occupation,	Coal mining, erecting supports
11100	6.0	Occupation,	Coal mining, general
11110	7.0	Occupation,	Coal mining, shoveling coal
11120	5.5	Occupation,	Construction, outside, remodeling
11130	3.5	Occupation,	Electrical work, plumbing
11140	8.0	Occupation,	Farming, bailing hay, cleaning barn, poultry work
11150	3.5	Occupation,	Farming, chasing cattle, nonstrenuous
11160	2.5	Occupation,	Farming, driving harvester
11170	2.5	Occupation,	Farming, driving tractor
11180	4.0	Occupation,	Farming, feeding small animals
11190	4.5	Occupation,	Farming, feeding cattle
11200	8.0	Occupation,	Farming, forking straw bales
11210	3.0	Occupation,	Farming, milking by hand
11220	1.5	Occupation,	Farming, milking by machine
11230	5.5	Occupation,	Farming, shoveling grain
11240	12.0	Occupation,	Fire fighter, general
11245	11.0	Occupation,	Fire fighter, climbing ladder with full gear
11246	8.0	Occupation,	Fire fighter, hauling hoses on ground
11250	17.0	Occupation,	Forestry, ax chopping, fast
11260	5.0	Occupation,	Forestry, ax chopping, slow
11270	7.0	Occupation,	Forestry, barking trees
11280	11.0	Occupation,	Forestry, carrying logs
11290	8.0	Occupation,	Forestry, felling trees
11300	8.0	Occupation,	Forestry, general
11310	5.0	Occupation,	Forestry, hoeing
11320	6.0	Occupation,	Forestry, planting by hand
11330	7.0	Occupation,	Forestry, sawing by hand
11340	4.5	Occupation,	Forestry, sawing, power
11350	9.0	Occupation,	Forestry, trimming trees
11360	4.0	Occupation,	Forestry, weeding
11370	4.5	Occupation,	Furriery
11380	6.0	Occupation,	Horse grooming
11390	8.0	Occupation,	Horse racing, galloping
11400	6.5	Occupation,	Horse racing, trotting
11410	2.6	Occupation,	Horse racing, walking
11420	3.5	Occupation,	Locksmith
11430	2.5	Occupation,	Machine tooling, machining, working sheet metal
11440	3.0	Occupation,	Machine tooling, operating lathe
11450	5.0	Occupation,	Machine tooling, operating punch press
11460	4.0	Occupation,	Machine tooling, tapping and drilling
11470	3.0	Occupation,	Machine tooling, welding
11480	7.0	Occupation,	Masonry, concrete
11485	4.0	Occupation,	Masseur, masseuse (standing)
11490	7.0	Occupation,	Moving, pushing heavy objects, 75 lbs or more (desks, moving van work)
11500	2.5	Occupation,	Operating heavy duty equipment/automated, not driving
11510	4.5	Occupation,	Orange grove work
11520	2.3	Occupation,	Printing (standing)
11525	2.5	Occupation,	Police, directing traffic (standing)
11526	2.0	Occupation,	Police, driving a squad car (sitting)
11527	1.3	Occupation,	Police, riding in a squad car (sitting)
11528	8.0	Occupation,	Police, making an arrest (standing)
11530	2.5	Occupation,	Shoe repair, general
11540	8.5	Occupation,	Shoveling, digging ditches
11550	9.0	Occupation,	Shoveling, heavy (more than 16 lbs $\cdot$ min^{-1})
11560	6.0	Occupation,	Shoveling, light (less than 10 lbs $\cdot$ min^{-1})
11570	7.0	Occupation,	Shoveling, moderate (10–15 lbs $\cdot$ min^{-1})

APPENDIX 1. Continued

11580	1.5	Occupation,	Sitting-light office work, in general (chemistry lab work, light use of handtools, watch repair or micro-assembly, light assembly/repair)
11585	1.5	Occupation,	Sitting-meetings, general, and/or with talking involved
11590	2.5	Occupation,	Sitting; moderate (heavy levers, riding mower/forklift, crane operation)
11600	2.5	Occupation,	Standing; light (bartending, store clerk, assembling, filing, xeroxing, put up Christmas tree)
11610	3.0	Occupation,	Standing; light/moderate (assemble/repair heavy parts, welding, stocking, auto repair, pack boxes for moving, etc.), patient care (as in nursing)
11620	3.5	Occupation,	Standing; moderate (assembling at fast rate, lifting 50 lbs, hitch/twisting ropes)
11630	4.0	Occupation,	Standing; moderate/heavy (lifting more than 50 lb, masonry, painting, paper hanging)
11640	5.0	Occupation,	Steel mill, fettling
11650	5.5	Occupation,	Steel mill, forging
11660	8.0	Occupation,	Steel mill, hand rolling
11670	8.0	Occupation,	Steel mill, merchant mill rolling
11680	11.0	Occupation,	Steel mill, removing slag
11690	7.5	Occupation,	Steel mill, tending furnace
11700	5.5	Occupation,	Steel mill, tipping molds
11710	8.0	Occupation,	Steel mill, working in general
11720	2.5	Occupation,	Tailoring, cutting
11730	2.5	Occupation,	Tailoring, general
11740	2.0	Occupation,	Tailoring, hand sewing
11750	2.5	Occupation,	Tailoring, machine sewing
11760	4.0	Occupation,	Tailoring, pressing
11766	6.5	Occupation,	Truck driving, loading and unloading truck (standing)
11770	1.5	Occupation,	Typing, electric, manual or computer
11780	6.0	Occupation,	Using heavy power tools such pneumatic tools (jackhammers, drills, etc.)
11790	8.0	Occupation,	Using heavy tools (not power) such as shovel, pick, tunnel bar, spade
11791	2.0	Occupation,	Walking on job, less than 2.0 mph (in office or lab area), very slow
11792	3.5	Occupation,	Walking on job, 3.0 mph, in office, moderate speed, not carrying anything
11793	4.0	Occupation,	Walking on job, 3.5 mph, in office, brisk speed, not carrying anything
11795	3.0	Occupation,	Walking, 2.5 mph, slowly and carrying light objects less than 25 lbs
11800	4.0	Occupation,	Walking, 3.0 mph, moderately and carrying light objects less than 25 lbs
11810	4.5	Occupation,	Walking, 3.5 mph, briskly and carrying objects less than 25 lbs
11820	5.0	Occupation,	Walking or walk downstairs or standing, carrying objects about 25–49 lbs
11830	6.5	Occupation,	Walking or walk downstairs or standing, carrying objects about 50–74 lbs
11840	7.5	Occupation,	Walking or walk downstairs or standing, carrying objects about 75–99 lbs
11850	8.5	Occupation,	Walking or walk downstairs or standing, carrying objects about 100 lbs and over
11870	3.0	Occupation,	Working in scene shop, theater actor, backstage, employee
12010	6.0	Running,	Job/walk combination (jogging component of less than 10 min) (T 180)
12020	7.0	Running,	Jogging, general
12030	8.0	Running,	Running, 5 mph (12 $min \cdot mile^{-1}$)
12040	9.0	Running,	Running, 5.2 mph (11.5 $min \cdot mile^{-1}$)
12050	10.0	Running,	Running, 6 mph (10 $min \cdot mile^{-1}$)
12060	11.0	Running,	Running, 6.7 mph (9 $min \cdot mile^{-1}$)
12070	11.5	Running,	Running, 7 mph (8.5 $min \cdot mile^{-1}$)
12080	12.5	Running,	Running, 7.5 mph (8 $min \cdot mile^{-1}$)
12090	13.5	Running,	Running, 8 mph (7.5 $min \cdot mile^{-1}$)
12100	14.0	Running,	Running, 8.6 mph (7 $min \cdot mile^{-1}$)
12110	15.0	Running,	Running, 9 mph (6.5 $min \cdot mile^{-1}$)
12120	16.0	Running,	Running, 10 mph (6 $min \cdot mile^{-1}$)
12130	18.0	Running,	Running, 10.9 mph (5.5 $min \cdot mile^{-1}$)
12140	9.0	Running,	Running, cross-country
12150	8.0	Running,	Running, general (T 200)
12160	8.0	Running,	Running, in place
12170	15.0	Running,	Running, stairs, up
12180	10.0	Running,	Running, on a track, team practice
12190	8.0	Running,	Running, training, pushing wheelchair, marathon wheeling
12195	3.0	Running,	Running, wheeling, general
13000	2.5	Self-care,	Standing-getting ready for bed, in general
13009	1.0	Self-care,	Sitting on toilet
13010	2.0	Self-care,	Bathing (sitting)
13020	2.5	Self-care,	Dressing, undressing (standing or sitting)
13030	1.5	Self-care,	Eating (sitting)
13035	2.0	Self-care,	Talking and eating or eating only (standing)
13040	2.5	Self-care,	Sitting or standing-grooming (washing, shaving, brushing teeth, urinating, washing hands, put on make-up)
13050	4.0	Self-care,	Showering, toweling off (standing)
14010	1.5	Sexual activity,	Active, vigorous effort
14020	1.3	Sexual activity,	General, moderate effort
14030	1.0	Sexual activity,	Passive, light effort, kissing, hugging
15010	3.5	Sports,	Archery (nonhunting)
15020	7.0	Sports,	Badminton, competitive (T 450)
15030	4.5	Sports,	Badminton, social singles and doubles, general
15040	8.0	Sports,	Basketball, game (T 490)
15050	6.0	Sports,	Basketball, nongame, general (T 480)
15060	7.0	Sports,	Basketball, officiating (T 500)
15070	4.5	Sports,	Basketball, shooting baskets
15075	6.5	Sports,	Basketball, wheelchair
15080	2.5	Sports,	Billiards
15090	3.0	Sports,	Bowling (T 390)
15100	12.0	Sports,	Boxing, in ring, general
15110	6.0	Sports,	Boxing, punching bag
15120	9.0	Sports,	Boxing, sparring
15130	7.0	Sports,	Broomball
15135	5.0	Sports,	Children's games (hopscotch, 4-square, dodgeball, playground apparatus, t-ball, tetherball, marbles, jacks, arcade games)
15140	4.0	Sports,	Coaching: football, soccer, basketball, baseball, swimming, etc.
15150	5.0	Sports,	Cricket (batting, bowling)
15160	2.5	Sports,	Croquet
15170	4.0	Sports,	Curling
15180	2.5	Sports,	Darts, wall or lawn
15190	6.0	Sports,	Drag racing, pushing or driving a car
15200	6.0	Sports,	Fencing
15210	9.0	Sports,	Football, competitive
15230	8.0	Sports,	Football, touch, flag, general (T 510)
15235	2.5	Sports,	Football or baseball, playing catch
15240	3.0	Sports,	Frisbee playing, general
15250	3.5	Sports,	Frisbee, ultimate
15255	4.5	Sports,	Golf, general
15260	5.5	Sports,	Golf, carrying clubs (T 090)
15270	3.0	Sports,	Golf, miniature, driving range
15280	5.0	Sports,	Golf, pulling clubs (T 080)
15290	3.5	Sports,	Golf, using power cart (T 070)
15300	4.0	Sports,	Gymnastics, general
15310	4.0	Sports,	Hacky sack
15320	12.0	Sports,	Handball, general (T 520)
15330	8.0	Sports,	Handball, team
15340	3.5	Sports,	Hang gliding
15350	8.0	Sports,	Hockey, field
15360	8.0	Sports,	Hockey, ice

APPENDIX 1. Continued

15370	4.0	Sports,	Horseback riding, general
15380	3.5	Sports,	Horseback riding, saddling horse
15390	6.5	Sports,	Horseback riding, trotting
15400	2.5	Sports,	Horseback riding, walking
15410	3.0	Sports,	Horseshoe pitching, quoits
15420	12.0	Sports,	Jai alai
15430	10.0	Sports,	Judo, jujitsu, karate, kick boxing, tae kwan do
15440	4.0	Sports,	Juggling
15450	7.0	Sports,	Kickball
15460	8.0	Sports,	Lacrosse
15470	4.0	Sports,	Moto-cross
15480	9.0	Sports,	Orienteering
15490	10.0	Sports,	Paddleball, competitive
15500	6.0	Sports,	Paddleball, casual, general (T 460)
15510	8.0	Sports,	Polo
15520	10.0	Sports,	Racketball, competitive
15530	7.0	Sports,	Racketball, casual, general (T 470)
15535	11.0	Sports,	Rock climbing, ascending rock
15540	8.0	Sports,	Rock climbing, rapelling
15550	12.0	Sports,	Rope jumping, fast
15551	10.0	Sports,	Rope jumping, moderate, general
15552	8.0	Sports,	Rope jumping, slow
15560	10.0	Sports,	Rugby
15570	3.0	Sports,	Shuffleboard, lawn bowling
15580	5.0	Sports,	Skateboarding
15590	7.0	Sports,	Skating, roller (T 360)
15600	3.5	Sports,	Sky diving
15605	10.0	Sports,	Soccer, competitive
15610	7.0	Sports,	Soccer, casual, general (T 540)
15620	5.0	Sports,	Softball or baseball, fast or slow pitch, general (T 440)
15630	4.0	Sports,	Softball, officiating
15640	6.0	Sports,	Softball, pitching
15650	12.0	Sports,	Squash (T 530)
15660	4.0	Sports,	Table tennis, ping pong (T 410)
15670	4.0	Sports,	Tai chi
15675	7.0	Sports,	Tennis, general
15680	6.0	Sports,	Tennis, doubles (T 430)
15690	8.0	Sports,	Tennis, singles (T 420)
15700	3.5	Sports,	Trampoline
15710	4.0	Sports,	Volleyball, competitive, in gymnasium (T 400)
15720	3.0	Sports,	Volleyball, noncompetitive; 6–9 member team, general
15725	8.0	Sports,	Volleyball, beach
15730	6.0	Sports,	Wrestling (one match = 5 min)
15731	7.0	Sports,	Wallyball, general
16010	2.0	Transportation,	Automobile or light truck (not a semi) driving
16020	2.0	Transportation,	Flying airplane
16030	2.5	Transportation,	Motor scooter, motor cycle
16040	6.0	Transportation,	Pushing plane in and out of hangar
16050	3.0	Transportation,	Driving heavy truck, tractor, bus
17010	7.0	Walking,	Backpacking, general (T 050)
17020	3.5	Walking,	Carrying infant or 15-lb load (e.g., suitcase), level ground or downstairs
17025	9.0	Walking,	Carrying load upstairs, general
17026	5.0	Walking,	Carrying 1- to 15-lb load, upstairs
17027	6.0	Walking,	Carrying 16- to 24-lb load, upstairs
17028	8.0	Walking,	Carrying 25- to 49-lb load, upstairs
17029	10.0	Walking,	Carrying 50- to 74-lb load, upstairs
17030	12.0	Walking,	Carrying 74+-lb load, upstairs
17035	7.0	Walking,	Climbing hills with 0- to 9-lb load
17040	7.5	Walking,	Climbing hills with 10- to 20-lb load
17050	8.0	Walking,	Climbing hills with 21- to 42-lb load
17060	9.0	Walking,	Climbing hills with 42+-lb load
17070	3.0	Walking,	Downstairs
17080	6.0	Walking,	Hiking, cross country (T 040)
17090	6.5	Walking,	Marching, rapidly, military
17100	2.5	Walking,	Pushing or pulling stroller with child
17110	6.5	Walking,	Race walking
17120	8.0	Walking,	Rock or mountain climbing (T 060)
17130	8.0	Walking,	Up stairs, using or climbing up ladder (T 030)
17140	4.0	Walking,	Using crutches
17150	2.0	Walking,	Walking, less than 2.0 mph, level ground, strolling, household walking, very slow
17160	2.5	Walking,	Walking, 2.0 mph, level, slow pace, firm surface
17170	3.0	Walking,	Walking, 2.5 mph, firm surface
17180	3.0	Walking,	Walking, 2.5 mph, downhill
17190	3.5	Walking,	Walking, 3.0 mph, level, moderate pace, firm surface
17200	4.0	Walking,	Walking, 3.5 mph, level, brisk, firm surface
17210	6.0	Walking,	Walking, 3.5 mph, uphill
17220	4.0	Walking,	Walking, 4.0 mph, level, firm surface, very brisk pace
17230	4.5	Walking,	Walking, 4.5 mph, level, firm surface, very, very brisk
17250	3.5	Walking,	Walking, for pleasure, work break, walking the dog,
17260	5.0	Walking,	Walking, grass track
17270	4.0	Walking,	Walking, to work or class (T 015)
18010	2.5	Water activities,	Boating, power
18020	4.0	Water activities,	Canoeing, on camping trip (T 270)
18030	7.0	Water activities,	Canoeing, portaging
18040	3.0	Water activities,	Canoeing, rowing, 2.0–3.9 mph, light effort
18050	7.0	Water activities,	Canoeing, rowing, 4.0–5.9 mph, moderate effort
18060	12.0	Water activities,	Canoeing, rowing, >6 mph, vigorous effort
18070	3.5	Water activities,	Canoeing, rowing, for pleasure, general (T 250)
18080	12.0	Water activities,	Canoeing, rowing, in competition, or crew or sculling (T 260)
18090	3.0	Water activities,	Diving, springboard or platform
18100	5.0	Water activities,	Kayaking
18110	4.0	Water activities,	Paddleboat
18120	3.0	Water activities,	Sailing, boat and board sailing, windsurfing, ice sailing, general (T 235)
18130	5.0	Water activities,	Sailing, in competition
18140	3.0	Water activities,	Sailing, Sunfish/Laser/Hobby Cat, keel boats, ocean sailing, yachting
18150	6.0	Water activities,	Skiing, water (T 220)
18160	7.0	Water activities,	Skimobiling
18170	12.0	Water activities,	Skindiving or scuba diving as frogman
18180	16.0	Water activities,	Skindiving, fast
18190	12.5	Water activities,	Skindiving, moderate
18200	7.0	Water activities,	Skindiving, scuba diving, general (T 310)
18210	5.0	Water activities,	Snorkeling (T 320)
18220	3.0	Water activities,	Surfing, body or board
18230	10.0	Water activities,	Swimming laps, freestyle, fast, vigorous effort
18240	8.0	Water activities,	Swimming laps, freestyle, slow, moderate or light effort
18250	8.0	Water activities,	Swimming, backstroke, general
18260	10.0	Water activities,	Swimming, breaststroke, general
18270	11.0	Water activities,	Swimming, butterfly, general
18280	11.0	Water activities,	Swimming, crawl, fast (75 yards $\cdot$ min^{-1}), vigorous effort
18290	8.0	Water activities,	Swimming, crawl, slow (50 yards $\cdot$ min^{-1}), moderate or light effort
18300	6.0	Water activities,	Swimming, lake, ocean, river (T 280, T 295)
18310	6.0	Water activities,	Swimming, leisurely, not lap swimming, general
18320	8.0	Water activities,	Swimming, sidestroke, general
18330	8.0	Water activities,	Swimming, synchronized
18340	10.0	Water activities,	Swimming, treading water, fast vigorous effort

APPENDIX 1. Continued

18350	4.0	Water activities,	Swimming, treading water, moderate effort, general
18360	10.0	Water activities,	Water polo
18365	3.0	Water activities,	Water volleyball
18370	5.0	Water activities,	Whitewater rafting, kayaking, or canoeing
19010	6.0	Winter activities,	Moving ice house (set up/drill holes, etc.)
19020	5.5	Winter activities,	Skating, ice, 9 mph or less
19030	7.0	Winter activities,	Skating, ice, general (T 360)
19040	9.0	Winter activities,	Skating, ice, rapidly, more than 9 mph
19050	15.0	Winter activities,	Skating, speed, competitive
19060	7.0	Winter activities,	Ski jumping (climb up carrying skis)
19075	7.0	Winter activities,	Skiing, general
19080	7.0	Winter activities,	Skiing, cross-country, 2.5 mph, slow or light effort, ski walking
19090	8.0	Winter activities,	Skiing, cross-country, 4.0–4.9 mph, moderate speed and effort, general
19100	9.0	Winter activities,	Skiing, cross-country, 5.0–7.9 mph, brisk speed, vigorous effort
19110	14.0	Winter activities,	Skiing, cross-country, >8.0 mph, racing
19130	16.5	Winter activities,	Skiing, cross-country, hard snow, uphill, maximum
19150	5.0	Winter activities,	Skiing, downhill, light effort
19160	6.0	Winter activities,	Skiing, downhill, moderate effort, general
19170	8.0	Winter activities,	Skiing, downhill, vigorous effort, racing
19180	7.0	Winter activities,	Sledding, tobogganing, bobsledding, luge (T 370)
19190	8.0	Winter activities,	Snow shoeing
19200	3.5	Winter activities,	Snowmobiling

APPENDIX 1. Compendium of Physical Activities.

01009	8.5	Bicycling,	Bicycling, BMX or mountain
01010	4.0	Bicycling,	Bicycling, <10 mph, general, leisure, to work or for pleasure (T115)
01020	6.0	Bicycling,	Bicycling, 10–11.9 mph, leisure, slow, light effort
01030	8.0	Bicycling,	Bicycling, 12–13.9 mph, leisure, moderate effort
01040	10.0	Bicycling,	Bicycling, 14–15.9 mph, racing or leisure, fast, vigorous effort
01050	12.0	Bicycling,	Bicycling, 16–19 mph, racing/not drafting or >19 mph drafting, very fast, racing general
01060	16.0	Bicycling,	Bicycling, >20 mph, racing, not drafting
01070	5.0	Bicycling,	Unicycling
02010	5.0	Conditioning exercise,	Bicycling, stationary, general
02011	3.0	Conditioning exercise,	Bicycling, stationary, 50 W, very light effort
02012	5.5	Conditioning exercise,	Bicycling, stationary, 100 W, light effort
02013	7.0	Conditioning exercise,	Bicycling, stationary, 150 W, moderate effort
02014	10.5	Conditioning exercise,	Bicycling, stationary, 200 W, vigorous effort
02015	12.5	Conditioning exercise,	Bicycling, stationary, 250 W, very vigorous effort
02020	8.0	Conditioning exercise,	Calisthenics (e.g., pushups, pullups, situps), heavy, vigorous effort
02030	4.5	Conditioning exercise,	Calisthenics, home exercise, light or moderate effort, general (T 150) (example: back exercises), going up & down from floor
02040	8.0	Conditioning exercise,	Circuit training, general
02050	6.0	Conditioning exercise,	Weight lifting (free weight, nautilus or universal-type), power lifting or body building, vigorous effort (T 210)

English Abstract

Obesity is a pathological excess of body fat. An environment with boundless food availability, and an increasingly sedentary lifestyle coupled with less chances for PA creates the perfect setting for obesity.

Previous studies in Lebanon show that prevalence of obesity in adults is significant. Suggested causes include low physical activity, inactive lifestyle, and nutritional intake. However, in adolescents, research shows that prevalence is low among girls as compared to boys, and as compared to girls in other countries.

The first aim was to assess the prevalence of overweight and obesity among Lebanese adolescents and to examine correlates of physical activity, inactivity, and quality of life with BMI status. The second aim was to determine the relation between Body Mass Index and percent body fat among girls and to investigate the effect of physical activity on this relation.

The work in this thesis was conducted across two phases. In phase one, 1000 participated. They completed a self-report questionnaire made up of several sections. Data from this phase was used in study 1. In phase two, 65 adolescent girls were recruited. Body weight and height were measured by standard anthropometric procedures. DXA whole body scans were performed and subjects completed a physical activity questionnaire. Data from this phase was used in study 2 and 3.

In Study one, based on international BMI cut off points, the prevalence of overweight and obesity is 22.5% and 7.8% in boys respectively, and 12.47% and 1.78% in girls respectively. Boys are more active than girls. Obesity in adolescence impairs quality of life and is more pronounced in girls.

Study two shows that girls demonstrate a higher body fat for a given BMI, based on this, the current prevalence of overweight and obesity is underestimated. Finally, study three suggests that by adding a simple validated self report questionnaire for physical activity, it may be possible to improve the relation between BMI and %BF.

Keywords: Adolescents, Body fat, BMI, Physical activity, Quality of life

Résumé en Francais

L’obésité est une pathologie définie par un excès de masse grasse. Un environnement caractérisé par une disponibilité illimitée de la nourriture, une augmentation de la sédentarité associée à une baisse de l’activité physique entraîne un état favorable à l’installation de l’obésité.

Les études menées au Liban montrent que la prévalence de l’obésité chez les adultes est importante. Les causes responsables de l’obésité sont nombreuses : le niveau faible d’activité physique, la sédentarité et l’augmentation des apports nutritionnels. Néanmoins, il a été montré que les filles Libanaises sont moins touchées par l’obésité et le surpoids par rapport aux garçons Libanais et aux filles dans d’autres pays.

Le premier but de cette thèse est d’évaluer les prévalences du surpoids et de l’obésité chez les adolescents Libanais et d’explorer les relations entre le niveau d’activité physique, l’inactivité, la qualité de vie et le statut pondéral. Le deuxième but était de déterminer la relation entre l’indice de masse corporelle et le pourcentage de masse grasse chez les adolescentes Libanaises et d’explorer l’influence du niveau d’activité physique sur cette relation.

Le travail effectué dans cette thèse a été réalisé en deux phases. Dans la phase 1, 1000 adolescents ont participé à cette étude. Tous les participants ont complété un auto-questionnaire. Les données recueillies dans cette phase ont été utilisées dans l’étude 1. Dans la phase 2, 65 adolescentes ont été recrutées. Les mesures anthropométriques (poids et taille) ont été réalisées. Des mesures DEXA ont été réalisées au niveau du corps entier pour évaluer la composition corporelle. Enfin, ces adolescentes ont complété un questionnaire d’activité physique. Les données recueillies dans cette phase ont été utilisées dans les études 2 et 3.

L’étude 1, se basant sur les valeurs de références mondiales de l’IMC correspondant au surpoids et à l’obésité montre qu’au Liban, 22,5 % et 7,8 % des garçons sont en surpoids et obèses respectivement. Chez les filles, 12,4 % sont en surpoids et 1,7 % sont obèses. Les garçons étant plus actifs que les filles. L’obésité pendant l’adolescence altère la qualité de vie chez les deux sexes et surtout chez les filles.

L’étude 2 montre que pour un IMC donné, les adolescentes libanaises affichent un pourcentage de masse grasse beaucoup plus élevé que prévu. Dès lors, les prévalences d’obésité et du surpoids dans la population Libanaise sont sous-estimées. Enfin, l’étude 3 suggère qu’en ajoutant un simple auto-questionnaire validé, il est possible d’améliorer la relation entre l’indice de masse corporelle et le pourcentage de masse grasse.

Mots clés : Adolescents, Graisse corporelle, IMC, Activité physique, Qualité de vie.