Introduction

The WHO defines obesity as a level of body fatness sufficiently high as to increase risk of morbidity or mortality ***(WHO, 2000)***. The body mass index (BMI) is the most common means of defining what constitutes a healthy body weight for adults and children ***(Katzmarzyk et al., 2007).*** Overweight is defined as a BMI ranged from the 85th percentile to < the 95th percentile for children of the same age and sex. While in obesity BMI is at or above the 95th percentile for children of the same age and sex ***(Barlow et al., 2007).*** Over the past 30 years, childhood overweight/obesity, often beginning in infancy and toddlerhood, has reached epidemic proportions, particularly among minority and/or low-income populations in high-income countries ***(Flegal et al., 2010)***. Rates of pediatric obesity (BMI ≥ 95th percentile) have almost tripled over the past 25 years, with current estimates showing a prevalence rate of 16% for girls and 18% for boys ***(Ogden et al., 2006)***. The prevalence of adolescent and childhood overweight and obesity in children living in Egypt, Brazil and Mexico has reached levels comparable to those seen in industrialized nations ***(Wang et al., 2006)***.

Studies made on the impact of psychological factors on obesity showed evidence on the relationship between stressors and childhood obesity ***(Gundersen et al., 2011).*** Households characterized as having less family cohesion, more conflict and

disruptive home environments increase the child's risk of being overweight/obese ***(Kitzmann et al., 2008 and Rhee, 2008).*** Also there is a strong support for an association between interpersonal violence in childhood and obesity, with physical abuse, sexual abuse, and peer bullying garnering the most empirical evidence ***(Midie and Matthews, 2011).***

Overweight and obesity has many physical and psychological adverse effects. The most immediate consequences of childhood obesity may be in terms of adverse social and psychological health ***(Lobstein et al., 2004).*** Overweight was shown to precede academic and social difficulties among children including lower scores on math and reading assessments, trouble with social relationships, and an increased frequency of internalizing behaviors such as sadness, loneliness and anxiety ***(Gable et al., 2008).*** Concerning physical health effects, overweight children are more likely to exhibit risk chronic disease such as hyperlipidemia, low high-density lipoprotein cholesterol, hypertension, and hyperinsulinemia ***(Morrison et al., 1999a, 1999b; Freedman et al. 1999; Chu et al. 1998; Csabi et al. 2000).*** Also diseases previously seen only in adults as type 2 diabetes and the metabolic syndrome have emerged among children as a consequence of rising obesity rates ***(Lobstein et al., 2004; Csabi et al., 2000; Weiss et al. 2004).***

Iron deficiency is probably the most prevalent single common micronutrient deficiency in the world today ***(Stoltzfus, 2001).***

Nutrition in childhood has a significant impact on lifelong health. Since obesity and iron deficiency are two of the most common nutritional disorders worldwide ***(Harris, 2004)***, many studies were done to see if there is a relation between them.

These studies showed that rates of iron deficiency are higher in overweight children and adults compared with their normal weight counterparts ***(Brotanek et al., 2007, Nead et al., 2004 and Yanoffet al., 2007)***. Originally, this kind of association had been attributed to erroneous dietary habits of obese` patients ***(Seltzer and Mayer, 1963)***, but it has been clarified that hypoferremia in obesity is not associated with dietary factors, and an inflammatory-mediated, functional iron deficiency was claimed ***(Anty et al., 2008, Menzie et al., 2008 and Yanoff et al., 2007)***. As serum ferritin is an acute-phase protein, soluble transferrin receptor is likely to be the best clinical measure of iron status in overweight individuals ***(Zimmermann et al., 2008)***. Soluble transferrin receptor concentrations are not significantly affected by inflammation, and are therefore useful in differentiating iron deficiency from inflammatory hypoferremia ***(Zimmermann and Hurrell, 2007)***.

Some studies stated that weight loss among obese children results in increase in iron absorption so improving iron status ***(Amato et al., 2011)***.

Aim of the Work

1. We are aiming at assessing iron status among overweight/ obese primary school children.

   Age group from 6 years till preadolescence or age 12 years with Tanner score ≤ 2.

2. To assess the effect of 6 months dieting program on iron status improvement in overweight/obese children.

3. To study the psychological basis of obesity in children as well as associated co-morbidities.

4. To assess the prevalence of obesity among primary school students.

CHILDHOOD OBESITY

Definition:

The Centers for Disease Control and Prevention (CDC) has defined overweight in children as falling between the 85th and 95th percentile for sex and age on the body mass index (BMI) growth chart. Obesity is defined as exceeding the 95th percentile for sex and age for BMI ***(Ogden et al., 2010).***

Various organizations have advocated different methods of classifying childhood obesity. For example, according to the CDC, the best tool for monitoring weight in children is the body mass index(BMI), which is first calculated based on the child's weight and height, then plotted according to age and gender on charts shown in figure 1 and 2 ***(CDC, 2011 and AAP, 2011).*** The World Health Organization (WHO) does not state a preference for one method over another, noting that measuring obesity is challenging because there is no standard definition worldwide. Thus, WHO has developed several charts and tables for clinicians to use to assess a child's weight status**.** These include weight-for-age, weight-for-height, BMI-for-age, and triceps skin fold-for-age, among others ***(WHO, 2011).*** The American Academy of Pediatrics (AAP) uses the same guidelines for BMI-for-age as the CDC to define childhood obesity and states that for children older than 2 years, BMI is an acceptable measure to assess obesity ***(AAP, 2011).***

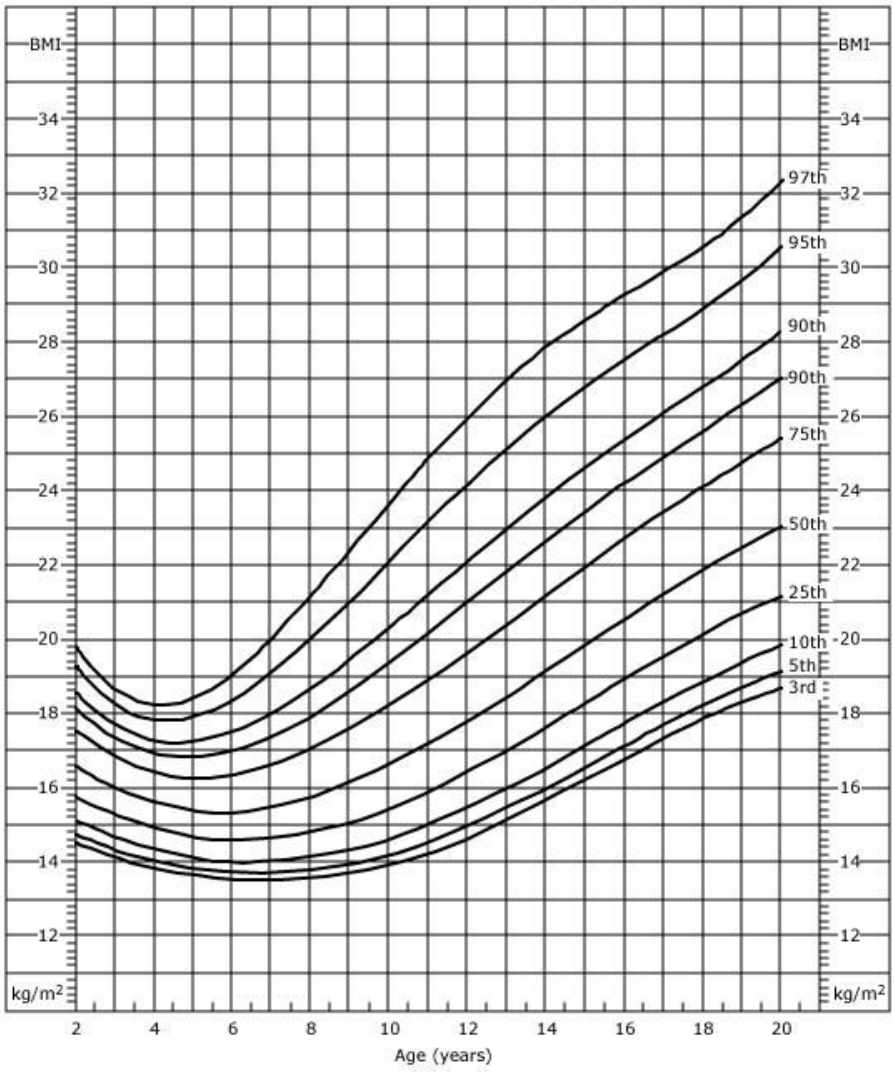

Figure (1): Body mass index-for-age percentiles, boys, 2 to 20 years, CDC growth charts: United States. Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000) ***(Baker et al., 2005).***

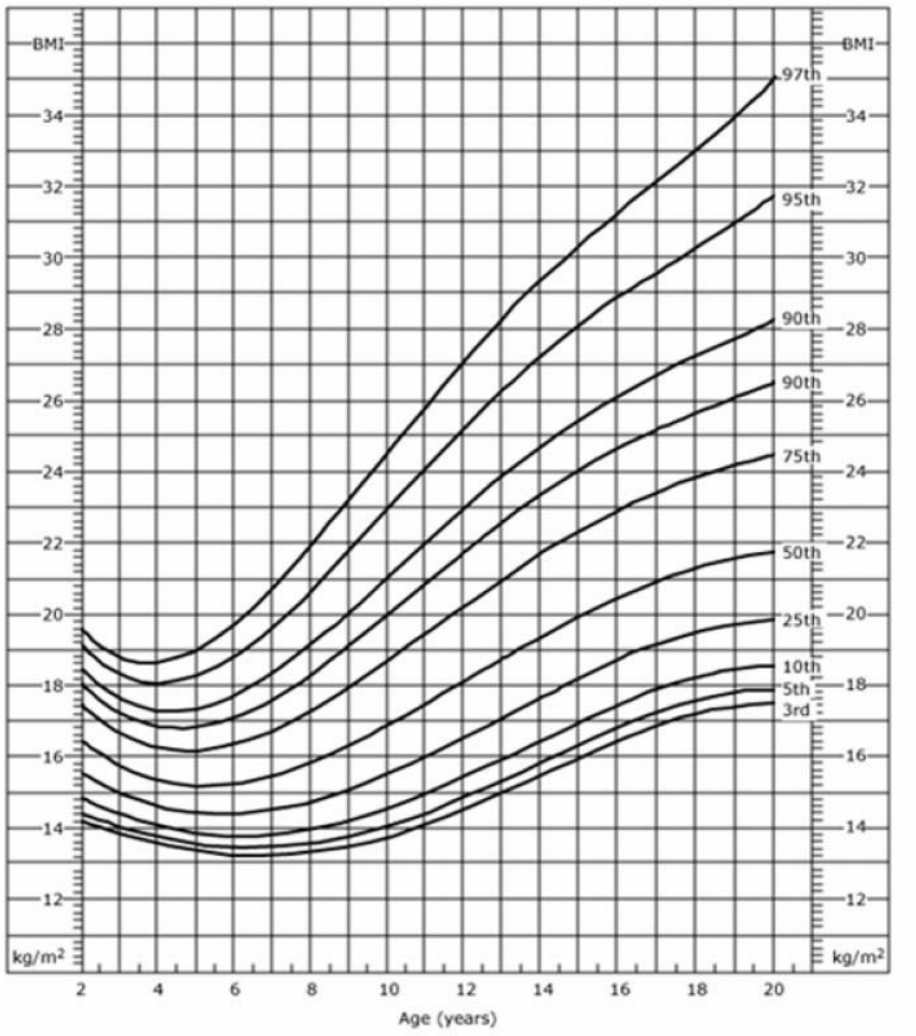

Figure (2): Body mass index-for-age percentiles, girls, 2 to 20 years, CDC growth charts: United States. Developed by the national Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000) ***(Baker et al., 2005).***

Prevalence

Over the past 30 years, childhood overweight/obesity, often beginning in infancy and toddlerhood, has reached epidemic proportions, particularly among minority and/or low-income populations in high-income countries ***(Flegal et al., 2010).*** The National Health and Nutrition Examination Survey (NHANES) has tracked obesity rates in children for the past four decades, and the prevalence of childhood obesity has risen steadily to epidemic proportion in our nation ***(Ogden et al., 2010).*** In 2010, 43 million children were estimated to be overweight and obese across the world, with 35 million in developing countries ***(de Onis et al., 2010)***.

In some Western settings such as the United States, western Europe, Australia, and Japan, recent data suggest that levels of childhood obesity may have reached a plateau in the last decade ***(Ogden and Carroll, 2012, Rolland-Caahera and Peneau, 2010 and Ogden et al., 2012)***.

However, the prevelance of obesity in children and youth remains alarmingly high. Among the 2-19 year-old population, 17% are obese, while nearly 10% of infants and toddler have excess weight ***(Ogden et al., 2010).*** The percentage of children aged 6–11 years in the United States who were obese increased from 7% in 1980 to nearly 18% in 2012. Similarly, the percentage of adolescents aged 12–19 years who were obese increased from 5% to nearly 21% over the same period

(National Center for Health Statistics, 2012 and Ogden et al., 2014). In 2012, more than one third of children and adolescents were overweight or obese The prevalence of childhood overweight and obesity is increasing, with worldwide prevalence has more than doubled in children and quadrupled in adolescents in the past 30 years ***(Ogden et al., 2014).*** The same trends have been observed in developing countries. For example, the prevalence of adolescent and childhood overweight and obesity in children living in Egypt, Brazil, and Mexico has reached levels comparable to those seen in industrialized nations ***(Wang et al., 2009)***.

Kelishad (2007) compared data from surveys on the prevalence of overweight and obesity among children living in developing countries. The highest prevalence of childhood overweight was found in Eastern Europe and the Middle East, whereas India and Sri Lanka had the lowest prevalence. Results of such studies are shown in **(figure 3).**

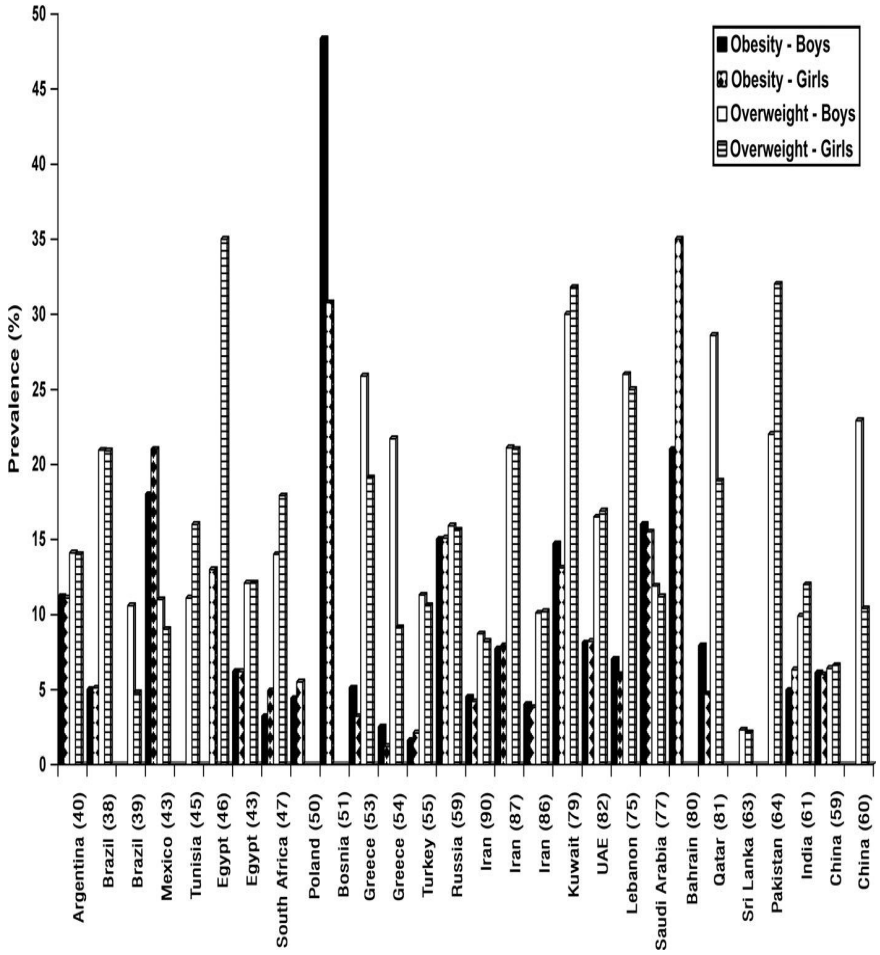

Figure (3): Prevalence of overweight/obesity in boys and girls aged 6–18 years in developing countries ***(Kelishadi, 2007).***

In 2010, the prevalence of childhood overweight and obesity in Africa was 8.5%, and it is expected to increase to 12.7% in 2020—a relative increase of 49%. In Asia, the estimated prevalence is lower than in Africa (4.9% in 2010, increasing to 6.8% in 2020), however, in absolute numbers, Asia has the highest number of overweight and obese children, because more than half (≈18 million in 2010) of the affected

children from developing countries live in this region. Of all the sub regions in 2010, Northern Africa has the highest prevalence by far (17%), which is driven mainly by Egypt (20.5% in 2008) and Libya (22.4% in 2007) ***(de Onis et al., 2010)***.

Factors:

1) Age:

The highest rate of obesity lies between the ages of 10 and 11 years; 21.89% of children within this age range are classified as obese. In the 12- to 14-year-old age range, 14.43% of children are considered obese. Finally, between the ages of 15 and 17 years, 10.72% of adolescents were found to be obese.

2) Socioeconomic status:

Increased prevalence of obesity is also linked to ethnicity and socioeconomic status. One study found a greater than threefold increase in risk of obesity in poor black children compared with wealthy white children. Household income and risk of childhood obesity are inversely proportional. As income increases, the risk of childhood obesity decreases ***(Singh et al., 2008)***.

3) Sex:

Concerning gender, in children 12 years and younger, gender discrepancy in the prevalence of childhood obesity is minimal. However, in children 12 to 17 years, gender

differences become more apparent. In one study, males 12 years and older were more likely than their female counterparts to become overweight ***(Boumitje et al., 2005 and Katie et al., 2011)***. This is believed to be the result of increased concern with body self-image among females in comparison to their male counterparts. Another study found that African American female children and Mexican American male children between 5 and 18 years maintain the highest prevalence of obesity; the reasons for this are unknown ***(Wieting, 2008)***.

Regionally in Egypt:

Latest statistics of the WHO revealed that obesity in Egypt could be considered as one of the highest rates worldwide. It's about 45% in women, 23% in men and 15% in adolescents and it is expected to reach 50% in women, 25% in men by the year 2015 ***(WHO Global Infobase, 2010)***.

Salaza et al. (2006) said that 12.1% of adolescents Egyptian (7% boys and 18% girls) were overweight, and 6.2% (6% boys and 8 % girls) were obese. ***Galal (2003)*** found that among Egyptian adolescents female, 35 percent of the girls were overweight and 13 percent were obese. In a study among adolescents female, the overweight was more prevalent in urban girls than in rural girls and more prevalent in girls with a higher socioeconomic status than in those with a lower socioeconomic status; 35% the girls were overweight and 13 % were obese ***(Jackson et al., 2003).***

Among Egyptian school children aged 8 to 12 years, the prevalence of overweight and obese students were 12.3 % and 15.1% respectively in private schools and were 13.4% and 6.7% in public schools ***(Shaalan et al., 2002).***

Hafez et al. (2000) studied children of primary school living in Greater Cairo, the prevalence of overweight and obesity were 14.3 % and 6.4% for boys, 13.8 % and 7.6 % for girls.

Pathophysiology:

During childhood and adolescence, excess fat accumulates when total energy intake exceeds total energy expenditure. This energy imbalance can result from excessive energy intake and/or reduced energy expenditure for body metabolism, thermoregulation, and physical activity. Increases in energy intake are observed in genetic syndromes, such as Prader-Willi syndrome, Cushing syndrome, drug-induced obesity, and certain mutations in genes that control appetite. Reductions in energy expenditure characterize hormonal deficiency states, including hypothyroidism and growth hormone deficiency ***(Schwarz and Freemark, 2010)***.

The energy balance equation dictates that obesity is the result of positive energy balance in which intake exceeds expenditure. In industrialised or developed countries the increase in childhood obesity is blamed on both increased

access to cheap high fat, high-energy foods and a simultaneous reduction in physical activity. Thus obesity is often viewed as a disease of development or wealth. However, the associations between obesity and the variety of other factors known to be associated with it such as ethnicity, socioeconomic status, age and gender are complex and only now being elucidated. For instance, in industrialised countries, adults of lower socioeconomic status tend to be overweight or obese, whilst in societies in economic transition or in emerging economies it is often the wealthy who display greater prevalence of obesity ***(Gail and Rampersaud, 2009).***

Appetite and fuel homeostasis are regulated in feedback circuits involving both regulatory hormones and signaling pathways in the central nervous system and the periphery. A lot of knowledge has been accumulated recently about the pathogenic mechanisms of obesity and its co-morbidity. Multiple factors are related to the high incidence of childhood obesity. Both genetic/endogenous and environmental/ exogenous factors contribute to the development of a high degree of body fatness early in life ***(Boucher et al., 2005)***.

Causes and risk factors:

Although the core of the problem of obesity can be simply stated as an imbalance between energy intake and energy expenditure over a prolonged period, the factors behind this are complex. The UK Foresight report described obesity as

a "complex web of societal and biological factors that have, in recent decades, exposed our inherent vulnerability to weight gain." That report presented an obesity system map with energy balance at its center being influenced by _100 variables acting at the individual, household, community, or wider societal levels ***(Butland et al., 2012).***

A) Early life risk factors:

A child's risk factors of becoming obese may even begin before birth ***(Gillman, 2008).***

Maternal weight and pregnancy: Maternal weight both before and during pregnancy, and the magnitude of weight gain during pregnancy, are linked to increased risk of overweight or obesity in the offspring ***(Cho et al., 2000 and Joseph et al., 2011)***. Maternal weight gain during pregnancy is also associated with a higher likelihood of childhood obesity, ***(Olson et al., 2010 and Oken et al., 2007)*** and the odds of having a child with a BMI above the 95th percentile at age 7 years increases by 3% for every kilogram of weight gained during pregnancy ***(Wrotniak et al., 2008 and Joseph et al., 2011)***.

Maternal diabetes: There is a positive association between maternal gestational diabetes mellitus and offspring overweight and obesity that is attenuated significantly after adjustment of prepregnancy BMI. The relationship between